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ERRATA

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- 26, line 12 from bottom, for *Leaniera hystericis* read *Leanira hystericis*
- 399, line 7, for *Cytharocyclis gigantea* read *Cyttarocyclis gigantea*.
- 399, line 8 from bottom, for *Aglantha digitate* read *Aglantha digitale*.
- 400, line 10, for *Rhizosolenia hebatata* f. *semispina* read *Rhizosolenia hebetata* f. *semispina*.
- 400, line 15, for *Rh. hebatata* f. *hiemalis* read *Rh. hebetata* f. *hiemalis*.
- 400, line 8 from bottom, for *P. pellucidim* read *P. pellucidum*.
- 401, line 8, for *C. denticulata* var. *media* read *C. denticulata* var. *media*.
- 401, line 15, for *Cyttarocyclis cuspitata* read *Cyttarocyclis cuspidata*.

EXPLANATION OF THE PLATES

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- 1-3. Rain-forest areas of British Guiana.
4. *Argiope bruennichi*.
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(ZOOLOGY)

The races of the European Wild Cat (*Felis silvestris*). By R. I. Pocock, F.R.S., F.L.S. (Unofficial Assistant in the Zoological Department of the British Museum).

[Read 1 March 1934]

SINCE Miller wrote his 'Catalogue of the Mammals of Western Europe', 1912, based upon the collections in the British Museum, some additional races of the European Wild Cat (*F. silvestris*) have been described, and the Museum has received some fresh specimens of the Scotch race (*grampia*), of the Central European race (*silvestris*), which he discussed, as well as of the Caucasian race (*caucasia*) which, beyond a brief reference, he omitted. Examination of the skins and skulls from Scotland, which amplified our knowledge of the British race, as recorded in the 'Scottish Naturalist', March-April 1934, induced me to compare them with the skins and skulls from the Continent and Asia Minor. Some unrecorded facts of sufficient interest to be put on record were brought to light and are embodied in this paper, which concludes with a table of cranial and dental measurements possibly useful for future reference.

The Scotch race

FELIS SILVESTRIS GRAMPIA Miller.

Felis grampia Miller, Ann. & Mag. Nat. Hist. (7) vol. xx, p. 396, 1907.

Felis silvestris grampia Miller, Cat. Mamm. West. Europe, p. 464, 1912; Pocock, Scottish Naturalist, March-April 1934, pp. 33-39.

Locality of type.—Invermoriston in Inverness-shire.

Distribution.—'The wilder parts of Scotland.'

Miller diagnosed this race as like the Central Continental and earlier described form, *silvestris*, but with the general colour darker and the pattern on the limbs and flanks tending to be better defined. The pattern, he added, resembles that of the South Spanish race, *tartessia*, but the general tint is more brownish and the size smaller, especially of the teeth.

The only materials of the Scotch race recorded in Miller's Catalogue were the skins and skulls contained in the British Museum. Most of the specimens, however, were young adult examples—all indeed which contained flesh measurements entered on the labels. Hence the measurements he recorded give a misleading impression as regards the size this cat may attain. Evidence of this is supplied by some fully adult examples sent in the flesh to the Museum since the War. These, weighed and measured according to modern methods, show that the Scotch Wild Cat much more nearly approaches the size of the large Spanish race than was previously supposed, and is larger on the available data than the typical Continental race. Of particular interest in the matter of size is an example sent from Ardgay, Ross-shire, in January 1934, by Sir R. W. Brooke. This is the largest known Scotch Cat authentically measured in the flesh*.

The new material also shows greater variation in the general colour and in the distinctness of the pattern than is exhibited by the skins Miller saw. One of the distinctive features of the Scotch race he mentioned was the absence of the 'frosted' appearance of the pelage, due to the clear pale grey areas of the hairs, which was noticeable to a varying degree in his specimens of the Central European and Spanish races. But an adult ♂ from Glenmoriston received from Mr. A. L. Marriott in 1920 is definitely 'frosted'—as grey indeed as in some of the Continental Cats. It is the palest of the Scotch series, and strikingly different from the darkest, another adult ♂ from Inverness (*J. Macpherson*, 1932), which is rich ochreous brown. Between these two extremes there is every gradation in tint. So too with the pattern. It is exceptionally heavy in a ♀ skin from Dundonnell (*Miss Firth*, 1916), the lateral stripes being nearly as black as the dorsal band, whereas in a ♂ from Spean Bridge (*The Cameron of Lochiel*, 1925) the pattern on the flanks is quite obscure, detectable merely as indistinct brindling. Here again there is every gradation between the extremes. But, although these additional specimens attest wider variation in colour and pattern than was known to Miller, they do not affect his general conclusion that the Scotch cat on the average is darker in hue, and has the pattern more pronounced than the Central European *silvestris*.

The following are the flesh measurements in English inches of three adult males—namely, those from Ardgay and Glenmoriston already mentioned, the third from Beauuly (*Sir L. Fletcher*, 1929). Unfortunately, none of the recently received females measured in the flesh is fully adult, and none is quite so large as the young adult ♀ from Invermoriston recorded by Miller :—

* For an account of alleged larger specimens, of which the dimensions were probably taken from stripped skins, see my paper in the 'Scottish Naturalist' quoted above,

	Head and body.	Tail.	Hind foot.
Ardgay, ad. ♂	25	14 $\frac{2}{3}$	5 $\frac{1}{3}$
Glenmoriston, ad. ♂	23 $\frac{1}{2}$	13	5 $\frac{2}{3}$
Beaully	22 $\frac{1}{2}$	12	5 $\frac{1}{2}$
Invermoriston, yg. ad. ♀	21 $\frac{2}{3}$	11 $\frac{2}{3}$	5

The weight of the Ardgay specimen was 15 lb. 10 oz.; of the Glenmoriston specimen 13 lb. 8 oz.

In the table of skull measurements (p. 4) I have cited only those of the largest and smallest adult males and of an old female, all being additions to the collection since the issue of Miller's Catalogue. It may be seen that the largest Scotch skull is only exceeded in dimensions by two in the table—namely, the exceptionally large skulls of the Spanish and Caucasian races. Two other adult ♂ skulls, one from Beaully (*Col. Clarke*) and one from Glenmoriston (*H. L. Marriott*), are 103 mm. in total length, the former having a condylobasal length of 97 mm., the latter of 95 mm. Measurements of the teeth in a number of skulls show that the length of the upper cheek teeth ranges from 30 to 33 mm., of pm^3+pm^4 from 17 to 19 mm., of the upper carnassial (pm^4) from 10 $\frac{1}{2}$ to 11 $\frac{1}{2}$ mm., of the three lower cheek teeth from 21 to 22 mm., and of the lower carnassial (m_1) from 8 to 9 mm. The ♀ skull is also larger than any recorded by Miller unless the adult unsexed skull from Sutherlandshire (*Harvie Browne*), which he queried as ♂, is ♀ as I suspect from its close agreement in dimensions with the old ♀ presented by A. H. Cocks.

The Central and Southern Spanish race

FELIS SILVESTRIS TARTESSIA Miller.

Felis tartessia Miller, Ann. & Mag. Nat. Hist. (7) vol. xx, p. 397, 1907.

Felis silvestris tartessia Miller, Cat. Mamm. West. Europe, p. 465, 1912; Cabrera, Fauna Iberica: Mamm., p. 205, pl. 9, fig. 2, 1914.

Locality of type.—Coto Doñana, Huelva, Andalucia.

Distribution.—Central and Southern Spain.

This race was originally known only from the western portion of Andalucia; but Cabrera traced its distribution northwards through Spain roughly to the south of the Ebro and upper waters of the Douro, and figured and described a specimen from El Pardo to the north of Madrid. In northern Spain—at Burgos, for example—it is replaced by a race at present inseparable from the central and western European race, *silvestris*.

No specimens have been received by the British Museum since Miller published his Catalogue *. My examination of the skins and skulls he saw confirms

* The history of these specimens entered in the Catalogue requires emendation. The type (no. 7.6.4.1), from Coto Doñana, Huelva, is recorded as collected and presented by Abel Chapman. It was collected by B. F. Buck and is an adult ♂ as stated in the tables of carnassial and dental measurements, not ♀ as stated where its skin measurements are given. The ♂ and ♀ skulls (nos. 2.6.3.2 and 3) were collected by Howard Saunders, who gave them to Dr. E. Hamilton, their precise locality in Andalucia being unrecorded. The large example (no. 8.3.8.1) from Huelva and the smaller specimen (no. 7.12.5.1) labelled Sierra Morena, north of Palma del Rio, were from Abel Chapman's collection.

TABLE I.

Cranial measurements in millimetres of *Felis silvestris*.

Name, locality, and sex.	Total length.	Condylol-basal length.	Zygomat-ic width.	Waist width.	Inter-orbital width.	Max-illary width.	Man-dibular length.
<i>F. s. grampia</i> (Scotland).							
Ardgay, Ross., ad ♂.....	106	99	76	37	22	28	73
Beauly, Ross., ad. ♂.....	101	93	74	33	22	27	69
? Invermoriston, Inverness., old ♀.	95	89	71	33	20+	26	65
<i>F. s. tartessia</i> (C. & S. Spain).							
Huelva, Andalucia, ad. ♂.....	109	103	80	32	23	32	74½
Andalucia, ad. ♂.....	103	(98±)	72	29	19	28½	69
Sierra Morena, Andalucia, ad. ♂ ?.	..	(96±)	73	33	20	26	67
Madrid (<i>Cabrera</i>), ad. ♂.....	..	92	78	34½	21+	..	69
Andalucia, yg. ad. ♀.....	..	(89±)	62½	31	16½	25	61
<i>F. s. silvestris</i> (W., C., & ? S. Europe).							
Tubingen, Württemberg, ad. ♂...	96	90	69	37—	20½	27	65
Moulins, C. France, ad. ♂.....	97	89	69	34	19	25	64
" " ad. ♂ ?	95	89	67	33½	19½	25	63—
S. Germany, ad.	93	85	68	34	18	24	60
Athens, ad. ♀ ? .....	..	88	69	35	19	24	63
<i>F. s. caucasica</i> (Asia Minor).							
Caucasus (<i>Ogneff</i>), ad. ♂.....	110—	102	78—	..	..	..	..
" " ad. ♂.....	97	90—	69	..	..	..	..
" " ad. ♀.....	99	91	72	..	..	..	..
" " ad. ♀.....	92½	85	65—	..	..	..	..
Caucasus (Brit. Mus.), ad., sex ?.	101	(95±)	69	34	17½	25½	..
Taurus (Brit. Mus.), ad. ♀ ?.	94	88	66	34—	18½	24	..

Figures in brackets, marked \pm , are estimated measurements on defective skulls. The total length is from the anterior margin of the premaxillae to the posterior edge of the occipital crest, which being a muscular ridge varies with age. The condylobasal length is from the same point to the edge of the occipital condyles. The maxillary width is taken a little above the socket of the canines. The mandible is measured from the symphysis to the angular point, a muscular process varying with age.

Some of my measurements differ slightly from Miller's where we have measured the same skulls. Discrepancies in fractions of a millimetre are practically inevitable in such cases. Small fractions of that unit I have in some instances indicated by the signs + and —.

his diagnosis of the race. The winter coat is not so full as in the northern races, the general colour is more frosted with grey than in average examples of *grampia*, less silvery than in average examples of *silvestris*; the pattern is on the average as distinct as in *grampia*, more distinct than in *silvestris*,

TABLE II.

Dental measurements in millimetres of *Felis silvestris*.

Name, locality, and sex.	Upper cheek- teeth.	$Pm^3 +$ Pm^4 .	Pm^4 (car- nassial).	Upper canine.	3 lower cheek- teeth.	m_1 (car- nassial).
<i>F. s. grampia.</i>						
Ardgay, ad. ♂	33	19	$11\frac{1}{2}$	6	22	8
Glenmoriston, ad. ♂	32	18	11	5	22—	9—
? Invermoriston, old ♀	31	19—	$11\frac{1}{2}$	5	..	..
<i>F. s. tartessia.</i>						
Huelva, Andalucia, ad. ♂	35	20	$12\frac{1}{2}$	7	23—	9+
Andalucia, ad. ♂	34	20	12	7	23	$9\frac{1}{2}$
Madrid (<i>Cabrera</i>), ad. ♂	$32\frac{1}{2}$	20+	..	..	23—	..
Sierra Morena, ad. ♂ ?	32	19	12	6	22—	$9\frac{1}{2}$
Andalucia, yg. ad. ♀	32	20	12+	6	23+	10
<i>F. s. silvestris.</i>						
Tubingen, ad. ♂	31	19	11	..	22	$8\frac{1}{2}$
Moulins, ad. ♂	30	$17\frac{1}{2}$	11—	6	20	8
Moulins, ad. ♂ ?	32	$18\frac{1}{2}$	$11\frac{1}{2}$	6	21	$8\frac{1}{2}$
Caterille, Haute Garonne, yg. ♂ .	29	17	11	4	20	8
Burgos, yg. ad., sex ?	29	$17\frac{1}{2}$	11	4	20	8
Burgos (<i>Cabrera</i>), ad. ♂	$29\frac{1}{2}$	$17\frac{1}{2}$	..	..	$20\frac{1}{2}$	..
Dobrudscha, yg. ♂	31	19—	12	6	22	9+
„ yg. ♀	31	$19\frac{1}{2}$	12	6	$22\frac{1}{2}$	$9\frac{1}{2}$
Athens, ad. ♀ ?	31	$19\frac{1}{2}$	12	5	23—	$8\frac{1}{2}$
<i>F. s. caucasica.</i>						
Nr. Trebizond (<i>trapezia</i>), yg. ad. ♂.	29	17	10	4+	20	8
„ „ yg. ad. ♂.	29—	18	$11\frac{1}{2}$	5	20	9—
„ „ yg. ad. ♂.	29	$18\frac{1}{2}$	11	5	$20\frac{1}{2}$	8
„ „ yg. ad. ♀.	..	..	..	4	20	8—
Caucasus, ad., sex ?	$32\frac{1}{2}$	$17\frac{1}{2}$	11	$5\frac{1}{2}$	..	..
Taurus, ad. ♀ ?	$30\frac{1}{2}$	$17\frac{1}{2}$	11	5	..	..

The length of the upper cheek-teeth is taken from the anterior edge of the canine at the base to the posterior edge of the minute molar. The measurement of the upper canine is its basal length at the point where the enamel ceases. The three lower cheek-teeth include the carnassial (m_1) and the two premolars in front of it.

and the skull and teeth are on the average larger than in either *grampia* or *silvestris*. As regards the flesh measurements of *tartessia*, the only record with which I am acquainted is that of the adult ♂ from near Madrid, described by Cabrera, in which the head and body were $25\frac{1}{5}$ in., the tail $12\frac{2}{5}$, the hind foot $5\frac{1}{5}$, the head and body being almost the same as in the largest known

example of *grampia* from Ardgay and the tail rather shorter* ; but the head and body were longer than in any recorded example of typical *silvestris*.

All the skulls in the British Museum, except one, have the occiput more or less defective. The complete skull is not only longer † than any skull of this Wild Cat from western or central Europe, but is better developed, being the only one known to me with a complete sagittal crest extending from the coronal suture to the occiput. In the rest the two temporal ridges are separated on the suture by a space, varying individually, but on the average narrower than in the skulls of *grampia* and still narrower than in skulls of *silvestris*.

The incompleteness of the occiput in the skulls mentioned above compelled Miller to estimate the condylobasal length of 2 ♂ and 1 ♀ skull from Huelva. The ♂ skulls he made approximately 93 mm. and the ♀ 84 mm. But, judging from the total length of the ♂ skulls and by the analogy supplied by other skulls of this Wild Cat, I think his estimate was too small, mine being approximately 98 for the ♂ and 89 for the ♀ skulls. An unsexed skull (no. 7.12.5.1) from Sierra Morena, given by Howard Saunders to Dr. Hamilton, I take to be ♂, but not so old as the other ♂ skulls in the collection. I make its condylobasal length 96 mm. approximately. Thus the average condylobasal length of these four skulls is 98 mm., as nearly as may be, according to my estimate—a little longer, that is to say, than in the four adult ♂ skulls of *grampia* ; and this is in keeping with the average greater total length of the Spanish skulls. But the condylobasal length of Cabrera's adult ♂ skull was only 92 mm., a trifle smaller than the smallest of the adult ♂ skulls of *grampia* known to me. This specimen, however, was collected near Madrid, considerably to the north of Andalucia, the district of typical *tartessia* ; and in that measurement the skull is intermediate in size between typical *tartessia* and *silvestris*, as the locality of the specimen is intermediate between the area occupied by *silvestris* in northern Spain and typical *tartessia* in southern Spain. The mandible of the large ♂ skull of *tartessia* is mislaid. I have, therefore, taken the length recorded by Miller, but I do not know whether he measured to the condyle or to the angular point.

The only ♀ skull of *tartessia* known to me is the one measured by Miller. It is an undeveloped young adult of approximately the same length as the old ♀ skull of *grampia*, but everywhere narrower because it is much younger ; and for the same reason the temporal ridges are a little wider apart on the coronal suture—namely, 19 mm.

The superiority in the size of the teeth of *tartessia* is shown in the table of measurements (p. 5). The measurements of the mandibular teeth of the large Spanish skull, for the reason given above, are taken from Miller's table.

* Miller's measurements of *tartessia* (head and body 26 in., tail 14 in., hind foot $5\frac{3}{8}$ in.) were taken from a made-up skin from Huelva.

† In the condylobasal length of this skull in Miller's Catalogue (p. 467) the decimal point has been misplaced. It clearly should be 103.2, not 10.32.

The typical Central European race

FELIS SILVESTRIS SILVESTRIS Schreb.

For synonymy, see Miller, *Cat. Mamm. West Europe*, p. 462, 1912.

Locality of type.—Germany.

Distribution.—Central Europe from France to the Black Sea and southwards into northern Spain, Italy, and probably Greece.

Since 1912 the Museum has received three skins of this race, one from Central France, the others from Rumania, which were not seen by Miller. A comparison of these with the rest of the skins reveals some interesting geographical cross resemblances. Of the old skins the darkest, from North Germany ♂ (no. 95.5.1.1), is very nearly the same tint as the greyest, most frosted of the skins of *grampia* from Glenmoriston, but the pattern is not so pronounced and, on the flanks and hind body, is more mottled and less striped. The palest and most silvery, also ♂, is from Salavon, Haute Marne (no. 95.11.9.2); in this the pattern shows up better, partly because of the silvery ground tint and partly because there is more black in it. Nearly intermediate between these two are a skin from Fugelheim in Hesse (no. 11.1.2.104) and one from Manonville, Meurthe-et-Moselle. The latter has the soles of the hind feet buffy, with a black patch on the outer side of the plantar pad, whereas the example from Salavon, from the same district of France, near Nancy, has the greater part of the sole sooty*.

A young ♂ skin from Casterille, Haute Garonne, in South France (no. 8.7.15.1), very closely resembles the North German skin, but is not quite so grey, a trifle more buffy; whereas a ♀ skin from Burgos in North Spain (no. 8.7.7.10) may be described as the twin of the North German skin. Another from Burgos (no. 8.7.7.11) is paler and greyer, nearly matching the skin from Manonville, but it has the pattern stronger than in any, nearly as strong as in the skin of *grampia* from Glenmoriston, which in general appearance it much more closely resembles than the Glenmoriston skin resembles the darker Scotch skins. Of the newer skins one, ♂, from the Monladier forest, near Moulins in Allier Dept., C. France (no. 19.7.7.3646) is remarkable for the absence of the grey frosted or silvery appearance in the others, the pale areas of the hairs being buffy, which, blending with their black tips, produces a generally brownish hue matched by many Scotch skins; but the buff pervades the base of the ears, the neck and limbs, as well as the body, and the pattern, except for the normal black upper stripes, is scarcely detectable. This skin, belonging to Lataste's collection, comes on the whole nearest to the skins from Haute Garonne, in South France, and Meurthe-et-Moselle in North-East France, and Fugelheim in Hesse, but is decidedly browner on the body and more buffy, less grey on the head. The two Rumanian skins were collected by Rettig in Dobrudscha on the coast of the Black Sea, the most easterly point in Central Europe whence this race has been recorded. One of them, ♀ (no. 12.5.23.2) from Testemel

* See below, under the description of the alleged Corsican race.

is very silvery and closely matches in tint and pattern the skin from Salavon, near Nancy, although the pattern is perhaps a little more pronounced. The other, ♂ (no. 12.5.23.1), from Baspunac, is less silvery, has the pattern more obscure, and nearly matches the example from Manonville, near Nancy. The skin from Athens, ♀ (no. 47.7.22.2), which was seen by Miller, although not quite like any of the others, falls into line with them. It is one of the darker skins, not frosted with clear grey, but with the pale areas of the hairs buffy grey, and rather extensively, so that the ground-tint is brighter and paler than in the skin from Haute Garonne, the one which perhaps it most nearly resembles. It is possible that the Grecian Cat, when better known, may prove to be racially distinct from the rest. In that case it will probably take the name *morea* alleged to have been given to a wild cat from Greece by Reichenbach (Vollst. Nat. Raubth. 1852), but I have been unable to refer to this work, the citation of which is taken from Trouessart's Catalogue.

The only flesh measurements of an adult of this race available to Miller were those of a ♂ from North Germany. Two years later Cabrera gave the dimensions of an adult ♂ from Burgos, North Spain (Fauna Iberica: Mamm. p. 204, 1914). To these may be added the measurements of the two examples from Dobrudscha in the British Museum, the millimetres in which each was recorded being converted into English inches, estimating the inch at 25 mm. :—

	Head and body.	Tail.	Hind foot.
North Germany, ad. ♂.....	21 $\frac{1}{2}$	12 $\frac{2}{3}$	5 $\frac{2}{3}$
Burgos, N. Spain, ad. ♂	23 $\frac{1}{2}$	10 $\frac{2}{3}$	4 $\frac{2}{3}$
Dobrudscha, yg. ad. ♂	22 $\frac{2}{3}$	13 $\frac{2}{3}$	5 $\frac{2}{3}$
„ yg. ad. ♀	20 $\frac{1}{2}$	13	5 $\frac{2}{3}$

Miller gave the dimensions of eight skulls assigned to this race—three from France, two from South Germany, and one each from Austro-Hungary, Bulgaria, and Athens. These I have seen, apart from the skull from Varna in Bulgaria, which belonged apparently to Knut Andersen, and would have been of special interest on account of its larger size*.

In my table of measurements I have supplemented Miller's records by the measurements of an adult ♂ skull from near Tubingen, Württemberg, and of two adults, one marked ♂, the other being probably ♂, from Moulins in Allier Dept., C. France (*Lataste*). These are slightly larger than those entered by Miller; but in conjunction with them they show that the French and German Wild Cats have smaller skulls than the Scotch, the largest adult ♂ skulls from France and Germany being smaller than the smallest adult ♂ Scotch Cat,

* It was, however, not quite so large as the skull from Baranza in Austro-Hungary recorded by Miller under this race; but this skull, I am convinced, is the skull of a domestic cat or, possibly, of a wild cat reared in captivity from kittenhood. It belonged to Dr. E. Hamilton, and was apparently given to him by a Countess Batthyany, who no doubt kept it as a pet. Hamilton regarded it as the skull of a wild cat and figured it as such, though without giving the source of the figure, on p. 50 of his book, 'The Wild Cat of Europe,' 1896.

although the latter is a little smaller than the skull from Varna in Bulgaria recorded by Miller. It is noticeable also that the Central European skulls have the muscular area on the crown wider on the average than in the Scotch skulls. In the Württemberg skull, which, although not old, has the postorbital processes touching on each side, the area is 22 mm. at the suture ; in one of the South German skulls (1143 *f*), with the processes almost touching, it is almost the same ; in the other South German skull, ♂ (1143 *d*), with the processes well separated, it is 19 mm. ; in the skull from Manonville and one of the skulls from Moulins it is 20 mm. ; but in the other skull from Moulins, ♂, its width is only 11 mm. as in the large skull of *grampia* from Ardgay. Nevertheless, the average in the six adult skulls is about 19 mm., as compared with 13½ mm. in the four adult Scotch skulls. Although the apparent difference may be purely a question of age, it is worth recording.

The only skull from Burgos, North Spain, in the British Museum, is a young adult, probably ♀ specimen ; but Cabrera recorded the measurements of an alleged adult ♂ from that locality. Since, however, this skull has a condylo-basal length of only 84½ mm. and is considerably smaller than adult ♂ French and German skulls and at the same time has a greater waist-width, 38½ mm., I suspect it is not fully developed. Its maturity was probably judged from the closure of the basioccipital suture. But this suture may be closed in *F. silvestris* before the skull has completed its development. This was the case in the skulls of *caucasica* from Trebizond (see p. 12) which, with this suture evanescent or absent, were regarded as fully adult and received a new name on that account.

A noticeable feature connected with the teeth is the large size of the carnassials (pm^4 and m_1) and upper canines in the two skulls from Dobrudscha. True, they are newly erupted and quite unworn. Nevertheless, they are obviously bigger, as also are the combined pm^3+pm^4 and the three lower cheek teeth, than in the skulls from Burgos, North Spain, and Haute Garonne, South France, which are not apparently older and should have the teeth equally unworn. The facts, coupled with the wide geographical area between the two pairs of skulls, suggest that eastern examples of this race may have bigger teeth than the south-western, the typical German forms being intermediate. This suggestion is supported by the small size of the teeth in the alleged adult ♂ skull from Burgos, recorded by Cabrera, and their large size in the fully adult example from Athens.

The skull from Athens, with the base and occiput broken away, has the teeth only a little worn. It is, nevertheless, obviously an oldish skull, as attested by the completed postorbital bars and the absence of all trace of the median fronto-parietal suture. For its age it is unusually smooth and rounded, there being no sign of the temporal ridges or of a sagittal crest. Its teeth are large as in the Dobrudscha skulls and as in them the nasals are long, considerably surpassing the maxillæ. Apart from age characters it apparently only differs from them in having the upper end of the premaxillæ noticeably broader where it is wedged between the nasals and maxillæ ; but this is an individually

variable character in European Wild Cats. The possibility of the Greek Wild Cat proving a distinguishable race and, if so, the name it will probably take, has been referred to above (p. 8) under the description of the skin.

The following two forms may prove to be races distinct from typical *silvestris* :—

Felis reyi Lavauden, C. R. Acad. Sci. clxxxix, p. 1023, 1929. Locality of type and distribution : Corsica.

This cat, said to occur everywhere, though seldom seen, in the mountains of Corsica, was described as differing from typical *silvestris* by its smaller size, very deep colour, and the blackness of the sole of the hind foot. The tint was said to be very deep, with grey and brown pattern (*ondé de gris et brun*), the face and flanks washed with reddish, this hue pervading the base of the coat, the ears blackish brown behind, the spinal stripe rather indistinct. The blackness of the sole of the foot is not a distinctive feature, the reddish hue suggests 'erythrism,' especially as the base of the coat in all normally coloured examples of *silvestris* is grey, and the phrase '*ondé de gris et brun*' recalls a close pattern of the so-called 'mackerel' type observable in some domestic cats rather than the pattern of *silvestris*. Moreover, the total length of the typical ♀ skin, given as 850 mm. (=34 in.), does not indicate the claimed inferiority in size, since it is very nearly the same as that of the adult ♂ of typical *silvestris* from North Germany recorded by Miller. Nevertheless, the only two measurements of the skull that are recorded do not coexist in any skull of any race of *silvestris* I have seen. The condylobasal length of 80 mm. suggests an immature specimen; but this conclusion is not in keeping with the zygomatic width of 70 mm., indicating complete maturity or even old age. There is only a difference of 10 mm. between the length and breadth, whereas in *silvestris* the difference is about 20 mm., a skull about 70 mm. wide being about 90 mm. long. It does not appear that Lavauden had more than the one specimen he recorded.

Felis molisana Altobello, Fauna dell' Abruzzo. Mamm. p. 55, 1921; id., Monitore Zool. Ital. 35, Rendiconto etc., p. 35, 1924. Locality of type : Molise. Distribution : Abruzzo, Molise, Campania in Central Italy.

Distinguished, according to Altobello, from typical *silvestris* by its colour which is described as greyish yellow, by its tail being more than half the length of the head and body, and by the stripes on the nape ceasing abruptly at the hinder end of the neck.

In the British Museum there is a single made-up skin from Rome (*E. C. Taylor*), which Miller identified as *F. silvestris silvestris*. In its obscure pattern and general colour it fits in with German and French skins of that race, and the tail is not in any way exceptional in length, being less than half the head and body. Moreover, in most skins of all the races of this European Wild Cat the tail is over half the length of the head and body. Very frequently, too, the nape

stripes cease abruptly at the end of the neck, although they reappear on the shoulders as a pair of sharply defined black stripes. In the skin from Rome the nape stripes cease at the end of the neck; but the skin is peculiar in the indistinctness of the stripes on the shoulder. They are visible, but faint, although the nape and spinal stripes are distinct and black as in the skins of other races of *F. silvestris*. That is apparently the only feature by which this skin from Rome is distinguishable from skins of typical *silvestris*. Altobello records *silvestris* from Tuscany in the north and Calabria in the south of Italy, the area of *molisana* cutting in between—a peculiar geographical arrangement of mammalian subspecies.

The Asia Minor race

FELIS SYLVESTRIS CAUCASICA Satunin.

Felis catus caucasicus Satunin, Mitth. Kauk. Mus. vol. ii, pp. 154 & 316, 1905.

Felis silvestris caucasicus Ogneff, Zeits. Säugetierk. vol. v, p. 52, 1930.

Felis daemon Satunin, Proc. Zool. Soc. 1904, p. 162; Smirnov, Bull. Mus. Cauc. vol. xi, pp. 84–6, 1918.

Felis sylvestris trapezia Blackler, Ann. & Mag. Nat. Hist. (8) vol. xviii, p. 73, 1916.

Locality of types of *caucasicus* and *daemon*, Caucasus; of *trapezia*, Khotz, near Trebizond.

Distribution.—The Caucasus and Asia Minor.

Note on the synonymy.—Satunin gave the name *daemon* to some Caucasian black cats, which, according to Smirnov, are a variety of *caucasicus*. I have added *trapezia* to the synonymy, because I cannot distinguish the known skins and skulls from Trebizond from a skin and skull from the Caucasus.

This race, judging from specimens in the British Museum—namely, a skin and skull from the Caucasus, four skins and skulls from near Trebizond,—differs from typical *F. s. silvestris*, represented by the examples from Germany and France, by its average duller, darker tint, more conspicuous, and broken up, spotty lateral pattern, and by one or two cranial features described below.

The skins vary individually in colour above from dark, dull, greyish or olivaceous brown, without any 'frosted' appearance as in the type of *trapezia* from Khotz, near Trebizond, to tawny grey with distinct 'frosted' appearance recalling the Central European race, as in two others from the same locality. A skin from Scalita, south of Trebizond, and the one from the Caucasus closely resemble the type, but are not quite so dark and like it are without the frosted tinge in the pelage. The pattern is distinct in all the skins, and is noticeable for the general incompleteness of the lateral stripes, which show a pronounced tendency to break up into spots.

The only flesh measurements of this race known to me personally are those of the four examples from near Trebizond, described as *trapezia*, which are shown by their skulls to be not fully grown. They are entered below. Measurements of several other examples were recorded by Satunin, but, since

they appear to have been taken from stripped skins, they may be set aside. For example, he gives the head and body length of one of his specimens of the black variety *daemon* as 30 in. and the tail as $15\frac{1}{2}$ in., including the hair. But the skulls do not bear out this exceptional size. I have, however, inserted below the dimensions (in inches) of two ♀ specimens recorded by Ogneff. The larger of these is admittedly a very big cat, considering its sex :—

	Head and body.	Tail.	Hind foot.
Nr. Trebizond, yg. ad. ♂.....	$22\frac{2}{5}$	12	$5\frac{1}{5}$
„ yg. ad. ♂.....	$21\frac{1}{5}$	$10\frac{3}{5}$	5
„ (type of <i>trapezia</i>)			
yg. ad. ♂.....	$21\frac{1}{5}$	$12\frac{1}{5}$	$5\frac{1}{5}$
„ yg. ad. ♀.....	$21\frac{3}{5}$	11	$4\frac{4}{5}$
Caucasus (<i>Ogneff</i>), ad. ♀.....	$25\frac{1}{5}$	$13\frac{1}{5}$	$5\frac{3}{5}$
„ „ ad. ♀.....	$21\frac{1}{5}$	$13\frac{4}{5}$	$5\frac{1}{5}$

In all the skulls the nasal bones, as Miller noticed, show either a much more abrupt constriction or at least a more marked emargination of the lateral edges about the middle of their length than in the western races. This feature is, however, variable, and is most emphatic in the type of *trapezia*, where the combined nasals are only 4 mm. wide at the points of the frontals. Also the nasals, on the average, are less prominent posteriorly, their hinder ends being on a level with the summits of the maxillae, not surpassing them, the extreme being presented by a skull from Taurus (*Danford*), in which they are 4 mm. below that point. In the western races the nasals, as a rule, surpass the maxillae, being very rarely on a level with them. The muzzle, too, is a little more constricted than in the western races. In the skull from the Caucasus and of the type of *trapezia* the width between the infraorbital foramina is 26 mm., in the skull from Taurus it is 27, whereas in skulls of similar size from France and Germany it is 28 or 29 mm.

In describing the Trebizond Cats as a race distinct from *caucasicus*, Blackler was deceived by the size of the skulls, which he considered to be adult. The ♂ skull of the type he stated, indeed, to be old. It is, like the others, unmistakably undeveloped, as attested especially by its open sutures, short narrow postorbital processes, and also by its general shape and size. It only differs from the skull of the Caucasus Cat, with which he compared it, in age-characters. This skull, of doubtful sex, is adult, but not old, and is naturally larger and better developed in every way. As shown by the table of measurements, it agrees tolerably closely in dimensions with two unsexed skulls of typical *caucasicus* and with the skull of the type (♀) of the black variety, *daemon*, recorded by Satunin. Ogneff, however, gave some measurements of two ♂ and two ♀ skulls of this race, the largest and smallest of each, which indicate unusual individual variation. The larger ♂ skull is practically as large as the largest known skull of the Andalucian race, *tartessia*, whereas the smaller, presumably

adult, is 12 mm. or more shorter, and is about the size of the adult ♂ skulls of the typical race *silvestris*, from France and Germany, known to me. The larger of his ♀ skulls slightly exceeds the smaller ♂, and surpasses the smaller ♀ by some 7 mm. The skull from Taurus, in the British Museum, no doubt ♀, is a little larger than Ogneff's smaller ♀.

As regards the teeth I have recorded in the table (p. 5) the measurements of those of the skulls from the Caucasus, Trebizond, and Taurus in the British Museum. They agree in size tolerably closely with those of *silvestris* and *grampia*, and also with the few tooth measurements of *caucasica* published by Satunin and Ogneff; but Satunin gives the lengths of the upper and lower carnassials (pm^4 and m_1) of the type of *daemon* as 12 and $9\frac{1}{2}$ mm. respectively; and Ogneff records the upper cheek teeth of a large ♂ of *caucasica* as 34 mm. These dimensions show that the teeth of individuals of *caucasica* may be as large as in some examples of *tartessia*; but, on the average, the teeth of *caucasica* are smaller.

SUPPLEMENTARY NOTE ON THE EUROPEAN WILD CAT.

In its distribution *Felis sylvestris* shows certain analogies to the Hare (*Lepus europaeus*) of western, central, and southern Europe; and, like the Hare, it entered Great Britain by the southern route, and thence made its way to the Highlands of Scotland. It was long ago exterminated in England, and at the beginning of the present century fears were entertained that a like fate might in the near future befall it in Scotland; but the World War afforded it respite from persecution as an enemy to grouse, and since that date it has considerably increased in numbers and extended its range.

On the *a priori* assumption that Europe was its original home, it seems probable from the available data that the species entered Asia Minor by the Turco-Grecian route to the south of the Black Sea, and thence passed on to the Caucasus; but it is perhaps equally likely that the cat is Asiatic in origin, and spread westwards into Europe. In favour of this view it may be pointed out that in one small particular the Caucasian race appears to be more primitive, namely, in its pattern being, on the average, more spotted, and that the specialized pattern of vertical stripes is most emphatic in the western forms of Great Britain and Spain.

According to my conception of the genus *, *F. sylvestris* is the most northern of the species of *Felis*, which is restricted in distribution to the warmer parts of the Eastern Hemisphere. *F. sylvestris* is not found in the islands of the Mediterranean, with the possible exception of Corsica, its place in Sardinia being taken by *F. ocreata sarda*, and in Crete by *F. ocreata agria* †, both of which

* Ann. & Mag. Nat. Hist. (8) vol. xx, pp. 333 & 349, 1917.

† Based upon specimens procured in the bazaar in Crete by Miss Bate, which, as I suggested in 1917, may be feral domesticated cats.

are races of a species, *F. ocreata*, very closely allied to *F. sylvestris*, and found almost all over Africa and in parts of S.W. Asia.

These two species are of exceptional interest from the practical certainty of their being the wild species whence the domestic cat, at least of the striped or 'mackerel' variety, was derived*. There is no reason to suppose any other species is concerned, although a third—namely, the Indian desert cat (*F. ornata*), which replaces *ocreata* to the east of its range—has been suggested as a possible contributor to the stock.

* For the evidence of this, see my paper, Proc. Zool. Soc. 1907.

On a collection of South African Polychaeta, with a catalogue of the species recorded from South Africa, Angola, Mosambique, and Madagascar.
By J. H. DAY, B.Sc. (Communicated by Dr. E. J. ALLEN, F.R.S., F.L.S.)

(With 16 Text-figures)

[Read 10 May 1934.]

INTRODUCTION.

During the years 1929–31 a collection of Polychaeta was made in South Africa and taken to England for description. These worms were collected between the tide-marks at St. James (False Bay), Port Alfred, East London, and Durban. But I have to thank first Dr. C. von Bonde the Director of the South African Fishery Survey for material obtained by the ss. *Pickle* and ss. *Africana*, secondly Mr. Hewitt and Dr. Smith for material from the Albany Museum at Grahamstown, and lastly Mr. Chubb for specimens from the Natal Museum at Durban.

The classification used in the description of this collection is that adopted by Professor Fauvel. At the commencement of the work it was found that an immense amount of literature had to be consulted to find the diagnostic characters of any species. This trouble is obviated in Fauvel's books (Fauvel, 1923 and 1927), where the addition of a short key saves hours of work. In describing species of which no summary is available a short diagnosis is given, which, it is hoped, will be useful in the same way.

Another difficulty that arose was the absence of a list of the species recorded from South African waters. Professor McIntosh (1924) gives a summary of several collections, but his list contains only one-third of the number in this catalogue. The number of species here recorded is 356. The value of any catalogue is increased if not merely the names of the species are given, but also the localities and a reference to a good description. This has been done; further, numbers in brackets are given at the end of each record to indicate the paper in the bibliography whence the record was obtained. Species recorded by the writer are denoted by an asterisk (*). Remarks as to temperature and depth have been excluded, partly because they are not always available, and partly because such detail is beyond the scope of this catalogue.

The main feature of the seas round South Africa is the presence of the Mosambique current flowing down the east coast towards the Cape and the cold Benguela current flowing northward along the west coast. In this connexion the variation of temperature along the coast is of great importance. The conditions may be summarized as follows:—Throughout the year the

sea is warmest along the Natal coast. As the Mosambique current flows southward the temperature falls slowly till Cape Agulhas is reached. At this point there is a mixture with the cold water of the West Wind Drift current and the temperature continues to fall as the Benguela current flows northward along the west coast, the full effect of the Benguela current being felt at Luderitzbucht, where minimum temperatures are experienced. North of this the temperature again rises.

Dividing the South African seas by a meridian through Cape Agulhas, the average yearly temperature of the west coast is 13.7°C . as against 17.1°C . for the south and eastern coasts. The maximum and minimum temperatures for the year 1930 were 23.4°C . at Durban and 10.1°C . at Hondeklip Bay near Luderitzbucht †.

The salinity follows the temperature. It is highest at Durban, falls along the coast-line round Cape Agulhas, reaches a minimum at Luderitzbucht, and then rises again.

On these lines the marine fauna can be divided into three groups :—

1. Species that occur on both the eastern and the western as well as the southern coasts. Such cases are listed as ‘ Round South Africa ’.

2. Species recorded from the west coast only, from such localities as Table Bay, Saldanha Bay, Luderitzbucht, and Swakopmund.

3. Species recorded from the south and east coasts only, from such localities as False Bay, Algoa Bay, Port Alfred, East London, and Durban.

Disregarding those species which have been recorded from False Bay or Table Bay only, since that area may be regarded as the region of overlap, it is found that when the species are separated into the three groups, 18 per cent are distributed round South Africa, 40 per cent are recorded from the west coast, and 42 per cent from the east coast. These incomplete records thus indicate that an equal number of species are found in the cold and the warm currents, but that a much smaller number are common to both.

In the catalogue the species recorded from Angola are included, as this area forms on the one hand the northern limit of species peculiar to South-West Africa. Such are : *Lepidonotus clava* var. *semitecta*, *Staurocephalus egenus*, *Stylarioides xanthotrichus*, and *Gunnarea capensis*. On the other hand, it also forms the southern limit of tropical species, such as *Harmothoe africana*, *Nephtys ambrizettana*, and *Stylarioides tropicus*.

On the east coast the same conditions prevail. Many of the tropical or subtropical species from Mosambique and Madagascar are found in Natal. Examples are : *Ceratonereis erythraensis*, *Eunice antennata*, *Stylarioides parmatum*, and *Sabellastarte indica*. Natal also forms the northern limit of many Cape species, such as *Lepidonotus clava* var. *semitecta*, *Eurythoe capensis*, *Euphrosyne capensis*, *Platynereis dumerilii* var. *striata*, *Stylarioides capensis*, and *Sabellastarte longa*.

† Figures from Reports 8 and 9 of the ‘ Fisheries and Marine Biological Survey of the Union of South Africa,’ published 1932.

It is thus evident that a certain number of species are peculiar to South Africa, their distribution on both coasts being limited by tropical or semi-tropical conditions. Examples are: *Lepidonotus clava* var. *semitecta*, *Euphrosyne capensis*, *Perinereis variegata*, *Lumbriconereis tetraura*, *Arenicola loveni*, *Gunnarea capensis*, and *Terebella pterochaeta*.

These lists are, of course, given tentatively to illustrate the general trend of distribution. Further work will show the exact limits.

In the collection itself there are many interesting species. Here it is necessary to recall only a few. *Lepidonotus clava* var. *semitecta* and *Lepidonotus durbanensis* form the two extremes of variation of the common stem form, *Lepidonotus clava*. Similarly, many Cape species are obviously the modified southern representatives of European species. Two common Cape species are of especial interest. The first is *Gunnarea capensis*, a tubicolous worm that gives harbourage within its enormous colonies to a host of marine forms. It lives commensally with *Polynoe scolopendrina* and probably with other species also. The second is *Audouinia filigera* var. *capensis* which shows a very fine example of protective imitation. It buries itself in the sand and coils up so that the protruding tentacles resemble those of an anemone.

My thanks are due to Dr. E. J. Allen and to Mr. C. C. A. Monro for advice and literature and to Dr. R. J. Daniel and Dr. Stanley Kemp for help in the preparation of the paper.

SUMMARY.

This paper contains a catalogue of the species of Polychaeta recorded from South Africa, Angola, Mosambique, and Madagascar, with a reference to a good description in each case. Within the catalogue are included the names of seventy-eight species collected in this region. Of these eight are new species, and many others have not been previously recorded for this region. A short diagnosis is given of many species where such is not readily obtainable.

APHRODITIDAE.

APHRODITE ALTA Kinberg.

McIntosh, 1924, p. 18.

Occurrence.—Mosambique to Table Bay (38).

PONTOGENIA CHRYSOCOMA Baird var. MINUTA Potts.

Potts, 1909, p. 329, pl. xx, figs. 26–7, pl. xxi, figs. 35–6.

Occurrence.—Madagascar (19).

HERMIONE HYSTRIX Savigny.

Fauvel, 1923, p. 35, fig. 11.

Occurrence.—North-east of Cape Point (38); Angola (21).

LAETMONICE FILICORNIS Kinberg.

Fauvel, 1923, p. 35, fig. 12 a–f.

Occurrence.—False Bay to South-West Africa (14, 28).

LAETMONICE PRODUCTA Grube.

Fauvel, 1923, p. 38.

Collected off the coast of Mosambique by the s.s. *Africana*. Two specimens. Length 71 mm., breadth 18 mm., number of segments 45. Colour in spirit pinkish mauve.

Remarks.—This species is new to South Africa, but has been described from the Antarctic by Ehlers, 1908. The larger of the two specimens had four Cirripede parasites attached between the parapodia.

Occurrence.—Mosambique (*).

MACELLICEPHALA MIRABILIS McIntosh.

McIntosh, 1885, p. 121, pl. xvi, fig. 1, pl. xii *a*, figs. 9–11; 1904, p. 59.

Occurrence.—False Bay and Saldanha Bay (35); off Cape Point (37).

LEPIDONOTUS CLAVA (Montagu).

Fauvel, 1923, p. 46, fig. 16 *a–e*.

Occurrence.—False Bay (18).

LEPIDONOTUS CLAVA (Montagu) var. **SEMITECTA** (Stimpson).

Lepidonotus clava semitectus Willey, 1904, p. 256, pl. xiii, fig. 4.

Lepidonotus semitectus Augener, 1918, p. 129.

Collected between the tide-marks at St. James and on the Bluff, Durban. Specimens numerous. Length up to 25 mm.

Diagnosis.—Similar to *L. clava*, but the tubercles on the elytra are long and cylindrical, those of *L. clava* being nodular or capstan-like. Elytra figured by Ehlers, 1913, pl. xxviii, figs. 5, 6.

Remarks.—The affinities of this species have already been discussed by McIntosh 1903, Ehlers 1908, and Augener 1918. The elytra of specimens from Durban show a closer approach to the typical *L. clava* form.

Occurrence.—Round South Africa.

LEPIDONOTUS STELLATUS Baird.

Augener, 1913, p. 98, with synonymy.

Occurrence.—Mosambique (19).

LEPIDONOTUS CRISTATUS Grube.

Gravier, 1901, p. 210, pl. vii, figs. 104–10, pl. ix, fig. 136; Fauvel, 1919, p. 329 (bibliography).

Occurrence.—Madagascar (19).

LEPIDONOTUS CARINULATUS Grube.

Horst, 1917, p. 69, pl. xv, fig. 10.

Occurrence.—Madagascar (19).

LEPIDONOTUS DURBANENSIS, sp. n.

Collected between the tide-marks on the Bluff, Durban. Three specimens. Length 28 mm.

Diagnosis.—Similar to *L. clava* in colouring, bristles, and shape of head. Papillae on the elytra large and spherical.

Description.—The general colour is reddish brown, with the tentacles and cirri marked in black. The prostomium is pale, the base of the tentacles

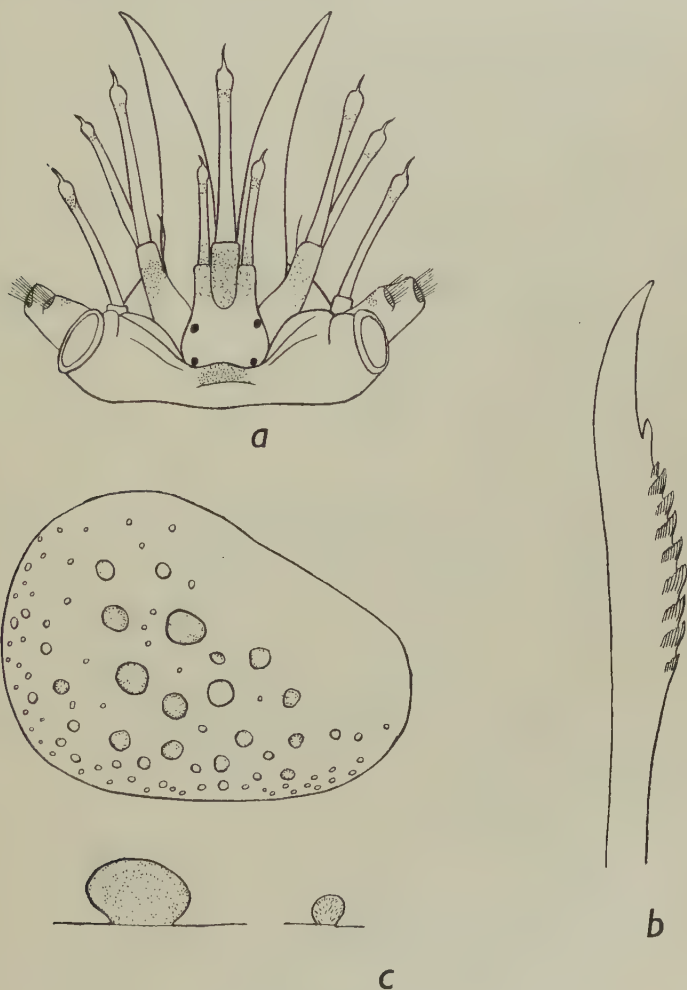


FIG. 1.—*Lepidonotus durbanensis*, sp. n.
a, head; b, ventral bristle; c, elytron and papillae.

pigmented. Both specimens are larger than the typical *L. clava*, but as usual the width of the body is uniform from head to anus.

The head (text-fig. 1 a) is typically *Lepidonotus* in form, with the tentacles inserted terminally. As in *L. clava*, the median tentacle and the tentacular cirri are shorter than the large palpi, and the lateral tentacles are only half the

length of the median. Both tentacles and tentacular cirri are smooth, with subterminal swellings and terminal filaments. The palpi, which have five rows of papillae, are tapered and also possess terminal filaments. The eyes are set in a rectangle as in *L. clava*, but the posterior are only slightly smaller than the anterior pair, and are partly hidden by a fold of the next segment.

The dorsal bristles, which are shorter and more numerous than the ventral group, are arranged in parallel series. They are of the usual pectinate type, slightly curved, and end in blunt points. The ventral bristles are large, brown, and bidentate, and the length of the webbed portion is equal to or greater than the length from spur to tip (text-fig. 1 b).

The dorsal cirri are similar to the tentacles. The ventral cirri are colourless and about one-third the length of the dorsal cirri. So far this species presents only a slight variation from the typical *L. clava*; it is the structure of the elytra which distinguishes this form. The scales (text-fig. 1 c), are oval in shape, with smooth margins. The first pair are orbicular, but the posterior pairs become more oval in shape. On all are large spherical papillae, which decrease in size on the posterior elytra. These papillae are apparently smooth, but on careful examination they show a honey-comb pattern. Besides these large ones there are many small ones which are capstan-like and covered with chitinous spicules as in *L. clava*.

Remarks.—*L. durbanensis* may prove to be no more than a variety of *L. clava*. If this is so then *L. clava* is represented in South Africa by two divergent forms, the variety *semitecta* in which the papillae are long and cylindrical and the variety *durbanensis* in which they are large and rounded.

Occurrence.—Durban (*).

LEPIDONOTUS TENUISSETOSUS (Gravier).

Euphione tenuisetosa Gravier, 1901, p. 222, pl. viii, figs. 123–6.

Occurrence.—Madagascar (19).

LEPIDONOTUS HUPFERI Augener.

Augener, 1918, p. 133, pl. ii, figs. 7–11, text-fig. 5.

Occurrence.—Angola (4).

LEPIDONOTUS TRISSOCHAETUS Grube.

Horst, 1917, p. 75; Fauvel, 1919, synonymy.

Occurrence.—Madagascar (19); Mosambique (43).

SHEILA BATHYPELAGICA Monro.

Monro, 1930, p. 43, fig. 8.

Occurrence.—Agulhas Bank (41).

EUNOA ASSIMILIS McIntosh.

McIntosh, 1924, p. 21, pl. ii, figs. 1, 2, pl. iii, fig. 3.

Occurrence.—Agulhas Bank (38).

HARMOTHOE CROSETENSIS (McIntosh).

Lagisca crosetensis McIntosh, 1885, p. 88, pl. viii, fig. 6, pl. xiii, fig. 2, pl. xviii, fig. 7, pl. xi a, figs. 4-6.

Harmothoe crosetensis Monro, 1930, p. 57.

Occurrence.—False Bay (41).

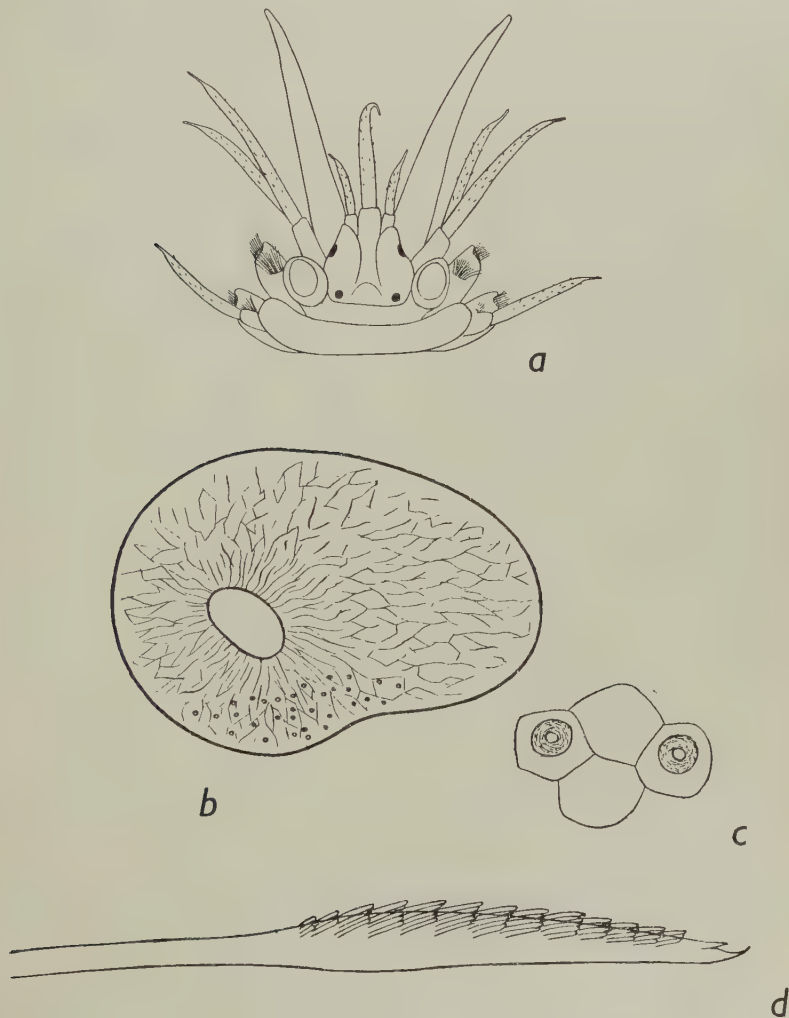


FIG. 2.—*Harmothoe waahli* (Kinberg).
a, head; b, elytron; c, papillae; d, ventral bristle.

HARMOTHOE WAAHLI (Kinberg).

Augener, 1913, p. 112, pl. ii, fig. 9; Monro, 1933, p. 489, figs. 1-3.

Collected between the tide-marks at St. James. One specimen. Length 11 mm., number of segments 34.

**Diagnosis*.—Body small, vermiform, pale grey. Head broader than long;

anterior pair of eyes well forward, lateral, twice the size of the posterior pair (text-fig. 2 *a*). Median tentacle longer than the head, laterals shorter. All tentacles tapering to filiform tips and sparsely covered with small clavate papillae. Palpi large. Dorsal cirri similar to tentacles and reaching to tips of ventral bristles. Elytra 14–15, covering the dorsum. Elytra large, transparent, and soft; margins smooth. Papillae few, minute, and conical (text-fig. 2 *b* & *c*). Dorsal bristles stout, with well-marked rows of spinules; tips blunt, often grooved. Ventral bristles bifid, superiorly with long blades, inferiorly with shorter broader blades (text-fig. 2 *d*).

Remarks.—This species has been recorded from Angola by Fauvel (1923 *a*) and from the Cape by Monro (1933). It is closely allied to *H. spinifera* Ehlers, and Monro regards it as the southern representative of this form. The differences from the latter species lie mainly in the character of the dorsal bristles, but other characters are to be noted, such as the comparative shortness of the median tentacle, which, in the Cape form at least, is only slightly longer than the head. Again, in the single specimen recorded here, the papillae are restricted to the inner half of the elytra. In those recorded by Monro and Augener they are scattered over the entire surface. Another point of interest is that in this specimen there are only 14 elytra pairs on segments 2, 4, 5, 7, 9, . . . 21, 24, 27, 30, . . . The tentacles and cirri are more evenly tapered than in *H. spinifera*. It also resembles *Eunoa assimilis* McIntosh, differing only in the character of the bristles.

Occurrence.—False Bay (*); Stil Bay (41); Angola (21).

HARMOTHOE AEQUISETA (Kinberg).

Augener, 1918, p. 137, synonymy.

Parmensis capensis Willey, 1904, p. 258, pl. xiii, figs. 7–8, 27–29.

Occurrence.—Round South Africa.

HARMOTHOE AFRICANA Augener.

Augener, 1918, p. 139, pl. ii, figs. 15–19, text-fig. 6.

Occurrence.—Angola (4).

HARMOTHOE DICTYOPHORA (Grube).

Willey, 1905, p. 251, pl. i, figs. 14–16; Fauvel, 1919, bibliography.

Occurrence.—Madagascar (19); Durban (32 *a*).

PARMENSIS RETICULATA McIntosh.

McIntosh, 1924, p. 25, pl. i, figs. 12–14, pl. iii, figs. 1–2.

Occurrence.—Mosambique (38).

SCALISSETOSUS PELLUCIDUS (Ehlers).

Fauvel, 1923, p. 74, fig. 27 *a–f*.

Occurrence.—False Bay (18); Saldanha Bay (4).

LAGISCA EXTENUATA (Grube).

Ehlers, 1913, p. 446.

Occurrence.—False Bay (17); Table Bay (32 a).

LAGISCA HUBRECHTI (McIntosh).

Fauvel, 1923, p. 78, fig. 29.

Occurrence.—Off the Cape of Good Hope (41).

POLYNOE CAPENSIS McIntosh.

McIntosh, 1885, p. 114, pl. iv, fig. 4, pl. xv, fig. 1, pl. xix, fig. 4, pl. ix a, figs. 4-5.

Occurrence.—Agulhas Bank (36).

POLYNOE SCOLOPENDRINA Savigny.

Fauvel, 1923, p. 80, fig. 30.

Collected at St. James, between the tide-marks. Fairly common. Length up to 66 mm., breadth 5 mm., number of segments 94.

Remarks.—At St. James specimens were found living commensally with *Gunnarea capensis*.

Occurrence.—Round South Africa.

POLYNOE CAPUT-LEONIS McIntosh.

McIntosh, 1924, p. 23, pl. ii, figs. 7, 8, 8 a.

Occurrence.—Agulhas Bank (38).

POLYNOE AGNAE McIntosh.

McIntosh, 1924, p. 21, pl. ii, figs. 3-4.

Occurrence.—Off Saldanha Bay (38).

LEPIDASTHENIA MICROLEPIS Potts.

Potts, 1909, p. 343, pl. xix, fig. 17, pl. xxi, fig. 52.

Occurrence.—Durban (32 a).

POLYEUNOA LAEVIS McIntosh.

McIntosh, 1885, p. 76, pl. xii, fig. 2, pl. xx, fig. 8, pl. vii a, figs. 12, 13.

Occurrence.—Agulhas Bank (35).

HALOSYDNA ALLENI, sp. n.

Collected between the tide-marks at St. James. Two specimens. Length 22 mm., breadth 4 mm., number of segments 45.

Diagnosis.—Eyes postero-lateral, almost fused. Tentacles short, smooth. Dorsal bristles few, minute. Elytra smooth, entire, pale, veined; 20-24 in number.

Description.—The body is vermiform and flattened. The general colour is pale grey with dark pigmented areas on the elytra. The head (text-fig. 3 a) is about as broad as long with a mid-dorsal groove running backwards from the base of the median tentacle. The eyes are postero-lateral in position and very close together on each side. The insertion of the tentacles is sub-terminal, the median tentacle arising from a notch and the laterals from prolongations of the prostomium. There is, however, a distinct division between

the base of the tentacles and the prostomium. The smooth median tentacle is pigmented distally and either cylindrical or slightly claviform, for the state of preservation does not permit of exact definition. The tentacles, tentacular

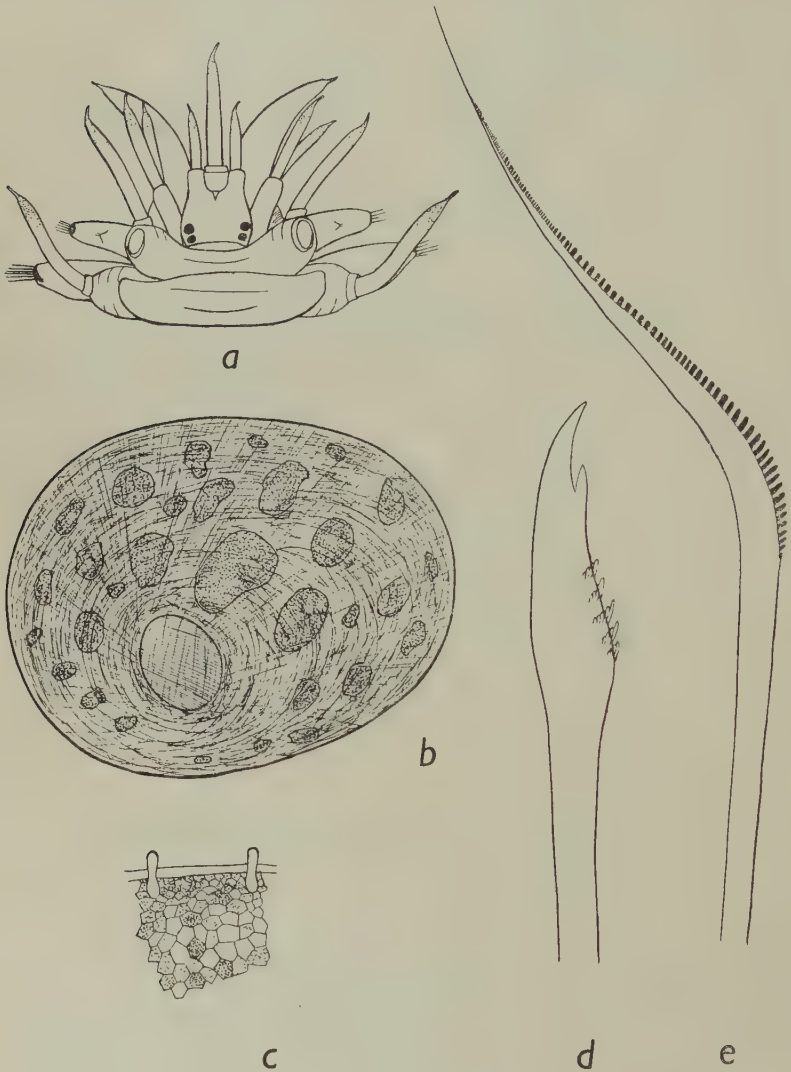


FIG. 3.—*Halosydna alleni*, sp. n.

a, head; b, elytron; c, marginal papilla; d, ventral bristle
e, dorsal bristle (greatly enlarged).

cirri, and the cirri end in filiform appendages. The lateral tentacles are similar to the median, but only two-thirds its length. The palpi are short and stout,

pale brown in colour, and scarcely longer than the median tentacle; the palpi also possess terminal filaments.

The elytra (text-fig. 3 *b*) numbered 20 in the small specimen and 24 in the larger one. On the latter they occurred on segments 2, 4, 5, 7, 9, . . . 23, 25, 28, 29, 32, 33, 36, 37, 40. Their position thus corresponds with those on *H. zeylandica*, described by Willey, whose specimens also had 20–24 elytra. It is certain, however, that the position of the elytra on the posterior segment of this and related genera is variable, as has been shown by Horst, 1917, for *Gastrolepidia calviger*. Each scale is rounded, transparent, and usually entire. In some cases, however, minute single-celled marginal papillae were seen (text-fig. 3 *c*). The surface is smooth, and nerve-twigs running from the attachment disc can be plainly seen.

The dorsal cirri arise from swollen bases, are cylindrical for most of their length, and taper at their apices to filiform appendages. Like the tentacles they are smooth and pigmented distally. In the first few segments they project beyond the bristle bundles, but posteriorly they barely reach the base of the ventral bristles.

The nodopodium is very small. There is a large aciculum, but never more than 2–3 minute bristles (see text-fig. 3 *e*). As in *Polynoe platycirrus* McIntosh, each bristle has a fine curved tip and a long, minutely dentate blade. Horst has shown that McIntosh's species is identical with *Halosydna fulvovittata* (Grube). The present species is easily distinguished from the latter by the character of the dorsal cirri, the shortness of the tentacles, and the position of the eyes.

The ventral ramus of the foot is very long, and possesses a brown aciculum and a group of about twelve bidentate bristles with short webs (see text-fig 3 *d*).

Remarks.—This species approaches both *H. fulvovittata* and *H. zeylandica*. The characters which distinguish it from the former have been stated above. It resembles Willey's species in the shape and position of the elytra. Though Willey does not describe the condition of the eyes or tentacles, it is easily distinguished by the ventral setae.

The three specimens were found in the tubes of *Gunnarea capensis*, and probably live there commensally.

Occurrence.—False Bay (*).

EUPHIONE ELISABETHAE McIntosh.

McIntosh, 1885, p. 62, pl. ix, fig. 3, pl. xvii, fig. 7, pl. xviii, fig. 10, pl. viii *a*, figs. 3–6; 1903, p. 27 (diagnosis).

Occurrence.—Round South Africa.

IPHIONE MURICATA (Savigny).

Gravier, 1901, p. 226, pl. ix, figs. 129–35; Fauvel, 1919, p. 334, with synonymy.

Occurrence.—Madagascar (19); Durban (32 *a*).

EULEPIS GEAYI Fauvel.

Fauvel, 1919, p. 335, pl. xv, figs. 17–21, pl. xvii, figs. 76–9.

Occurrence.—Madagascar (19).

HEMILEPIDIA ERYTHROTAENIA Schmarda.

McIntosh, 1924, p. 26, pl. ii, figs. 9-10.

Occurrence.—Table Bay (46); Luderitzbucht (40); Agulhas Bank (38).

GASTROLEPIDIA CLAVIGERA Schmarda.

Horst, 1917, p. 84, pl. xvi, fig. 5; Fauvel, 1919, p. 335, with synonymy.

Occurrence.—Madagascar (19).

PANTHALIS OERSTEDI Kinberg var. *CAPENSIS* McIntosh.

McIntosh, 1924, p. 31.

Occurrence.—Off East London (38).

PANTHALIS MELANONOTUS Grube.

Fauvel, 1919, p. 339, pl. xv, figs. 1-3, pl. xvii, figs. 70-5.

Occurrence.—Madagascar (19).

SIGALION OCULATUM Peters.

Peters, 1854, p. 610.

Occurrence.—Mosambique (43).

SIGALION MATHILDAE Audouin & M.-Edwards.

Fauvel, 1923, p. 103, fig. 39 *a-l*.

Occurrence.—Madagascar (19).

STHENELAIS BOA (Johnston).

Fauvel, 1923, p. 110, fig. 41 *a-l*.

Collected at St. James and Port Alfred between the tide-marks. Specimens common. Length up to 60 mm., number of segments 108.

Occurrence.—Round South Africa.

EUTHALENESSA DENDROLEPIS (Claparède).

Fauvel, 1923, p. 114, fig. 42 *h-o*.

Occurrence.—Agulhas Bank (14); off Natal (38).

LEANIERA HYSTRICIS Ehlers.

Fauvel, 1923, p. 118, fig. 43 *h-m*.

Occurrence.—Cape Point to Port Nolloth (38).

LEANIRA INCISA Grube.

Augener, 1918, p. 107, with synonymy.

Occurrence.—Angola (41).

PHOLOE MINUTA Fabricius.

Fauvel, 1923, p. 120, fig. 44 *a-h*.

Occurrence.—False Bay (17, 18).

PHOLOE MINUTA var. *INORNATA* Johnston.

Augener, 1918, p. 118.

Occurrence.—South-West Africa (4).

AMPHINOMIDAE.

AMPHINOME ROSTRATA (Pallas).

McIntosh, 1885, p. 21, pl. i, fig. 7, pl. iv, fig. 1, pl. i a, fig. 16, pl. ii a, figs. 8-12.

Amphinome pallasii Quatrefages; Fauvel, 1923, p. 127, fig. 46 a-g.

Dredged by the s.s. *Pickle* off East London. Two specimens. Length 90 mm., breadth 15 mm., number of segments 48.

Remarks.—Fauvel and Potts have distinguished this form under the name of *A. pallasii*, but, as McIntosh (1924, p. 9) remarks, the differences are probably due to methods of preservation and the variability of this widely distributed species.

Occurrence.—Off East London (*); Durban (38).

AMPHINOME INCARUNCULATA Peters.

Peters, 1854, p. 610; Augener, 1913, p. 92.

Occurrence.—Mosambique (43).

EURYTHOE COMPLANATA (Pallas).

Eurythoe alcyonia Savigny; Gravier, 1901, p. 248, figs. 257-68, pl. ix, figs. 140-3, pl. x, figs. 144-6.

Occurrence.—Madagascar (19); Natal (32 a).

EURYTHOE CAPENSIS Kinberg.

McIntosh, 1924, p. 12, pl. i, figs. 1-2.

Eurythoe assimilis McIntosh, 1924, p. 14, pl. i, figs. 5-6.

Collected at Umkomaas (Natal) between the tide-marks, also dredged by the s.s. *Pickle* off Durban. Six specimens. Length up to 88 mm., breadth 12 mm., number of segments 86.

Diagnosis.—Cephalic lobe small, pentagonal; caruncle reaching to fourth setiger, crest lobed. Median tentacle shorter than laterals. Eyes not evident. Gills commencing on the second segment, branching twice to produce finger-like tips. Dorsal bristles of three types: stout spurred forms; slender spurred forms; stout barbed forms. Ventral bristles stout, spurred and yellow.

Remarks.—McIntosh founded the species *E. assimilis* on specimens in which the barbed dorsal bristles predominate. In the present collection there are intermediate forms and also varieties in which each of the three types of dorsal bristles predominate.

Occurrence.—Table Bay (34); Natal (*); Mosambique (38).

PHERECARDIA LOBATA Horst.

Horst, 1911, p. 17, fig. 1; 1912, p. 32; Fauvel, 1919, p. 349, synonymy.

Occurrence.—Mosambique (38); Madagascar (19).

CHLOEIA GILCHRISTI McIntosh.

McIntosh, 1924, p. 15, pl. i, figs. 7-8.

Collected in sandy mud at Durban by Mr. Bevin. One specimen. Length 55 mm., breadth 12 mm., number of segments 34.

Diagnosis.—Body oval, colour grey-brown. No markings on dorsum. Median tentacle tapering, three-fourths length of caruncle; laterals slightly shorter; palpi one-third length of median tentacle. Eyes 4, equal in size but indistinct. Caruncle grooved longitudinally and transversely lobed, free posteriorly, reaching fourth segment. Branchiae commencing on the same segment near dorsal bristle-bundle; each gill roughly triangular, consisting of a stout trunk with 5–6 paired branches, the number of branches increasing to ten on posterior segments. Dorsal cirri long and tapering. Dorsal bristles of three types (text-fig. 4 *a*): stout and serrated along one side; stout and simple; fine and colourless. Ventral bristles (text-fig. 4 *b*) long and

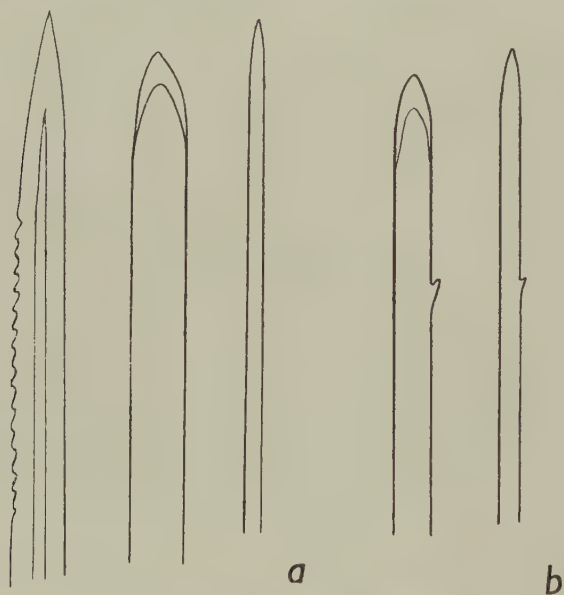


FIG. 4.—*Chloeia gilchristi* McIntosh.

a, dorsal bristles; *b*, ventral bristles.

slender, with or without a minute spur. Urites long and cylindrical, about four times as long as broad.

Remarks.—It is probable that the markings on the dorsum have faded. In these as well as McIntosh's specimens the bristles are badly preserved. In this one, however, most of the dorsal bristles retain the characteristic *Chloeia* brittleness, and some have a minute spur. These characters were lacking in McIntosh's specimens. In both examples some of the dorsal bristles show minute serrations. It is impossible to say how much the form of the bristles has been modified by the strong formalin in which the specimens had been preserved.

This species may well prove to be identical with *Chloeia euglochis* Ehlers. The main differences are in the bristles, the shape of the urites, and the number

of body segments. Until the bristles and coloration of a well-preserved specimen have been examined it is as well to keep them separate.

Occurrence.—Natal (38, *).

CHLOEIA CANDIDA Kinberg.

McIntosh, 1924, p. 17, pl. i, figs. 9, 10.

Occurrence.—Durban (38).

CHLOEIA FUSCA McIntosh.

Potts, 1909, p. 356, pl. xlv, figs. 1-2.

Occurrence.—Durban (32 a).

EUPHROSYPNE CAPENSIS Kinberg.

McIntosh, 1885, p. 1, pl. ii, fig. 5, pl. i a, figs. 1-3.

Collected at St. James, Fish River Point, Port Alfred, and East London. Specimens common. Length up to 40 mm., breadth 10 mm., number of segments 55.

Diagnosis.—Body oval, in life brick-red, in spirit brown. Eyes four. Median tentacle short, conical; laterals smaller. Caruncle with two flattened lateral ridges and a median keel, reaching sixth or seventh setiger. Body segments with 10 to 11 short branchial trunks, branching to end in bulbous tips as in *E. foliosa*. Dorsal bristles bifid and of two types: smooth and slightly curved; serrated and doubly curved. Ventral bristles bifid, smooth, and simply curved.

Remarks.—This species is common round the South African shores from Walvis Bay to Durban. It is found in the crevices of rocks near the low tide-marks. The bristles vary greatly in length of spur and degree of curvature, but on the whole resemble those of *E. borealis*.

Occurrence.—Round South Africa.

EUPHROSYPNE MYRTOSA Savigny.

Fauvel, 1923, p. 139, fig. 49 k-n.

Occurrence.—South-West Africa (4); False Bay (II, I4).

CHRYSOPETALIDAE.

PALEONOTUS CHRYSOLEPIS Schmarda.

Augener, 1913, p. 163, pl. xxxvii, figs. 326-9.

Occurrence.—Table Bay (46); Luderitzbucht (4).

BHAWANIA GOODEI Webster.

Augener, 1918, p. 98, pl. ii, figs. 1, 2, text-fig. 1.

Collected between the tide-marks at St. James. One specimen. Length 28 mm., breadth 1.5 mm., number of segments 110.

Remarks.—The head is damaged and description therefore impossible. The body is vermiform, and the paleae similar to those figured by Augener. The feet have numerous heterogomph bristles, a few superior ones bearing long

articulated portions, and below these a series with shorter blades. Above the setae there is a group of small bristle-like paleae. There is no indication of a dorsal cirrus.

This species is probably identical with *B. cryptocephala* Gravier, which has also been recorded from the Cape by Monro. No essential difference could be found in the form of the bristles or paleae, though the present specimen agrees more closely with those figured by Augener. Until the head of the Cape form has been described it is as well to keep the Atlantic form (*B. goodei*) separate from the species described by Gravier from the Indian Ocean and the Red Sea.

Occurrence.—Angola (4); False Bay (*).

BHAWANIA CRYPTOCEPHALA Gravier.

Gravier, 1901, p. 263, pl. x, figs. 152–6, text-figs. 280–5.

Occurrence.—Stil Bay (42); Madagascar (19).

PHYLLODOCIDAE.

PHYLLODOCE MACROPTHALMA Schmarda.

Fauvel, 1923, p. 146, fig. 51 *f–g*.

Occurrence.—False Bay (17).

PHYLLODOCE OCULATA Ehlers.

Ehlers, 1887, p. 135, pl. xl, figs. 4–6.

Occurrence.—Angola (4, 41).

PHYLLODOCE RUBIGINOSA Saint-Joseph.

Fauvel, 1923, p. 155, text-fig. 55 *d–g*.

Collected at St. James between the tide-marks. Four specimens. Length up to 48 mm., breadth 1 mm., number of segments 147.

Remarks.—This species reaches a large size in South African waters. It differs from the European form in the shape of the prostomium, which is comparatively larger and more regularly cordiform. It thus approaches *Ph. oculata* Ehlers, from which it is distinguished by the shortness of the tentacular cirri and the absence of notches on the anterior lateral margins of the prostomium. Both species have been recorded from this region by Augener.

Occurrence.—False Bay (*); South-West Africa (4).

PHYLLODOCE AFRICANA Augener.

Augener, 1918, p. 171, pl. ii, fig. 25, pl. iii, figs. 49–51, text-fig. 11.

Occurrence.—Angola (4).

EULALIA VIRIDIS (O. F. Muller).

Fauvel, 1923, p. 160, fig. 57 *a–h*.

= *Eulalia capensis* Schmarda, 1861.

= *Eulalia viridis* var. *capensis* McIntosh, 1903, p. 34.

Collected between the tide-marks at St. James. Specimens common. Length up to 64 mm., breadth 4 mm., number of segments 170.

Remarks.—The examination of many specimens shows that the slight differences between the Cape and European forms noted by McIntosh are not constant. They are probably due to the larger size attained by the Cape form.

Occurrence.—Round South Africa.

STEGGOA MICROCEPHALA (Claparède).

Augener, 1918, p. 174, pl. iii, figs. 55, 56, text-fig. 12.

Occurrence.—Angola (4).

NOTOPHYLLUM SPLENDENS (Schmarda).

Augener, 1913, p. 140, text-fig. 11, with synonymy.

Occurrence.—Table Bay (46).

ETEONE SPETSBERGENSIS Malmgren.

Malmgren, 1867, p. 102, pl. xv, fig. 38.

Occurrence.—False Bay (36).

MYSTIDES ANGOLAËNSIS Augener.

Augener, 1918, p. 178, pl. ii, figs. 32-4.

Occurrence.—Angola (4).

LOPADORHYNCHUS KROHNII (Claparède).

Fauvel, 1923, p. 185, fig. 68 *a-d*.

Occurrence.—24° S., 12° E. (41).

ALCIOPIDAE.

ALCIOPA CANTRAINII (Delle Chiaje).

Fauvel, 1923, p. 203, fig. 76.

Occurrence.—33° S., 16° E. (41).

VANADIS FORMOSA Claparède.

Fauvel, 1923, p. 205, fig. 77 *a-c*.

From plankton hauls taken in False Bay, April 1931. One specimen.

Occurrence.—Agulhas Bank (41); False Bay (*); off Natal Coast (38).

RHYNCHONERELLA FULGENS Greeff.

Fauvel, 1923, p. 210, fig. 79 *a-d*.

Occurrence.—South Atlantic (41); Indian Ocean (17).

TORREA CANDIDA (Delle Chiaje).

Monro, 1930, p. 82, synonymy.

Asterope candida Fauvel, 1923, p. 202, fig. 75 *a-d*.

Occurrence.—Agulhas Bank (41).

CALLIZONA ANGELINI (Kinberg).

Fauvel, 1923, p. 215, fig. 81 *d-i*.

Occurrence.—35° S., 10° E. (41).

TOMOPTERIDAE.

TOMOPTERIS (JOHNSTONELLA) APSTEINI Rosa.

Fauvel, 1923, p. 220, fig. 83 *a-d*.

From plankton samples taken in False Bay in October, and between Cape-town and Saldanha Bay in April. Specimens common. Length up to 14 mm., number of segments 16 plus 6 rudimentary tail-segments.

Remarks.—All the specimens were small. The frontal groove is broad and shallow, and there are gonads in both rami of the feet. In some of the smallest the tail was either very short or absent altogether. This is the first record from South Africa.

Occurrence.—False Bay (*); off Dassen Island (*).

TOMOPTERIS NISSENI Rosa.

Fauvel, 1923, p. 222, fig. 83 *e-g*.

Occurrence.—Off South-West Africa (4I).

TOMOPTERIS CAVALLII Rosa.

Fauvel, 1923, p. 222, fig. 84 *a*.

Occurrence.—34° S., 16° E. (4I).

TOMOPTERIS CARPENTERI Quatrefages.

Benham, 1921, p. 61, pl. vii, figs. 64–6.

Occurrence.—Agulhas Bank (39, 4I).

TYPHLOSCOLECIDAE.

SAGITELLA CORNUTA Ehlers.

Ehlers, 1913, p. 527, pl. xxxix, figs. 8–14.

Occurrence.—35° S., 14° E. (4I).

SAGITELLA KOWALEWSKII Wagner.

Fauvel, 1923, p. 228, fig. 85 *a-c*.

Occurrence.—34° S., 17° E. (4I).

SAGITELLA LOBIFERA Ehlers.

Ehlers, 1912, p. 24, pl. iii, figs. 1–4.

Occurrence.—35° S., 15° E. (4I).

TRAVISIOPSIS CAPENSIS McIntosh.

McIntosh, 1924, p. 40, pl. v, figs. 3, 3 *a*.

Occurrence.—Durban (38).

HESIONIDAE.

HESIONE PANTHERINA (Risso).

Fauvel, 1923, p. 233, fig. 87.

Occurrence.—Cape (II); Mosambique (38).

HESIONE GENETTA Grube.

Grube, 1878, p. 104; Fauvel, 1919, p. 370.

Occurrence.—Madagascar (19).

LEOCRATES CLAPAREDII (Costa).

Fauvel, 1923, p. 237, fig. 88 *i-n*.

Collected between the tide-marks at Durban. One specimen. Length 21 mm., breadth (including parapodia) 5 mm., number of segments 17.

Remarks.—This is the first record of this species from South Africa. The example has a proportionately smaller head and shorter palpi than the European form figured by Fauvel (fig. 88 *i*). There are six cirri round the anus; two are urites, and the others are the dorsal and ventral cirri of the reduced 17th setiger, of which only these cirri and the acicula remain.

Occurrence.—Durban (*).

ORTHODROMUS SPINOSUS Ehlers.

Ehlers, 1908, p. 61, pl. vii, figs. 1-7.

Occurrence.—Angola; South-West Africa (4, 14).

MAGALIA CAPENSIS McIntosh.

McIntosh, 1924, p. 41, pl. v, fig. 2.

Occurrence.—Off Saldanha Bay (38).

SYLLIDIA ARMATA Quatrefages.

Augener, 1918, p. 227.

Occurrence.—False Bay (17); South-West Africa (4).

IRMULA SPISSIPES Ehlers.

Ehlers, 1913, p. 468, pl. xxix, figs. 11-13.

Occurrence.—False Bay (17).

ANCISTROSYLLIS ROBUSTA Ehlers.

Ehlers, 1908, p. 59, pl. vi, figs. 4-7; Augener, 1918, p. 229.

Occurrence.—Angola (4); South-West Africa (14).

SYLLIDAE.

SYLLIS (HAPLOSYPHIS) DJIBOUTIENSIS Gravier.

Gravier, 1900, p. 147, pl. ix, fig. 3; Augener, 1913, p. 213, synonymy.

Occurrence.—Madagascar (19).

SYLLIS (HAPLOSYPHIS) SPONGICOLA Grube.

Fauvel, 1923, p. 257, fig. 95 *a-d*.

Occurrence.—Angola (4, 21).

SYLLIS LONGISSIMA Gravier.

Gravier, 1900, p. 154, figs. 17-23, pl. ix, fig. 7, text-figs. 17-23; Fauvel, 1919, p. 352, with synonymy.

Occurrence.—Madagascar (19).

SYLLIS GRACILIS Grube.

Fauvel, 1923, p. 259, fig. 96 *f-i*.

Collected between the tide-marks at St. James and Port Alfred. Six specimens. Length up to 29 mm., breadth 0.6 mm., number of segments 130.

Remarks.—The South African form differs very slightly from the European type. The anterior pair of eyes are further apart, and the shaft-heads of the large bristles with deciduous apices are not symmetrically or deeply forked. It thus approaches *S. amica*, from which it is easily distinguished by the dorsal cirri, which have the normal 9–12 articulations of *S. gracilis*.

Occurrence.—Round South Africa.

SYLLIS (TYPOSYLLIS) PROLIFERA Krohn.

Fauvel, 1923, p. 261, fig. 97 *a-g*.

Occurrence.—False Bay (18).

SYLLIS (TYPOSYLLIS) VARIEGATA Grube.

Fauvel, 1923, p. 262, fig. 97 *h-n*.

Collected between the tide marks at Port Alfred and St. James. Length up to 16 mm., breadth 1.0 mm., number of segments 92. Specimens numerous.

Occurrence.—Round South Africa.

SYLLIS (TYPOSYLLIS) ZONATA (Haswell).

Augener, 1913, p. 195, pl. iii, fig. 22, text-fig. 21 *a-c*.

Occurrence.—Cape; South-West Africa (4).

SYLLIS (TYPOSYLLIS) BRACHYCHAETA Schmarda.

Augener, 1918, p. 247, pl. iv, figs. 83–5, pl. v, fig. 98, text-fig. 20, with synonymy.

Occurrence.—Round South Africa (4, 42).

SYLLIS (TYPOSYLLIS) HYALINA Grube.

Fauvel, 1923, p. 262, fig. 98 *a-b*.

Occurrence.—False Bay to Angola (4, 18, 41).

SYLLIS (TYPOSYLLIS) EXILIS Gravier.

Gravier, 1900, p. 160, pl. ix, fig. 9, text-figs. 28–30; Fauvel, 1919, p. 354, synonymy.

Occurrence.—Madagascar (19).

SYLLIS (TYPOSYLLIS) VITTATA Grube.

Fauvel, 1923, p. 263, fig. 98 *i-l*.

Collected between the tide-marks at St. James. Four specimens. Length up to 22 mm., breadth 1.5 mm., number of segments 82.

Remarks.—This species has not been recorded from South Africa before. It is easily distinguished from the more common *S. variegata* by the thickness of its body and the comparative slenderness of its cirri.

Occurrence.—False Bay (*).

SYLLIS (TYPOSYLLIS) ARMILLARIS Malmgren.

Fauvel, 1923, p. 264, fig. 99 *a-f*.

Occurrence.—False Bay; off Saldanha Bay (38).

SYLLIS (TYPOSYLLIS) BOUVIERI Gravier.

Gravier, 1900, p. 163, pl. ix, fig. 10, text-figs. 31–34.

Occurrence.—Madagascar (19).

SYLLIS (TYPOSYLLIS) CAPENSIS McIntosh.

McIntosh, 1885, p. 193, pl. xxxiii, figs. 8–9, pl. xv *a*, fig. 21.

Occurrence.—Off Cape Point (35).

SYLLIS (EHLERSIA) CORNUTA Rathke.

Fauvel, 1923, p. 267, fig. 100 *g-i*, with synonymy.

Occurrence.—Round South Africa.

SYLLIS (EHLERSIA) FERRUGINA Langerhans.

Fauvel, 1923, p. 269, fig. 100 *k-u*.

Occurrence.—Angola (4).

TRYPANOSYLLIS ZEBRA Grube.

Fauvel, 1923, p. 269, fig. 101 *a-e*.

Occurrence.—Stil Bay (42).

TRYPANOSYLLIS INGENS Johnston.

Parlin Johnston, 1902, *American Naturalist*, vol. xxxvi, no. 424, April 1902, p. 295;

McIntosh, 1924, p. 42, pl. v, figs. 1, 1 *a*, 1 *b*.

Occurrence.—Table Bay (38).

TRYPANOSYLLIS GEMMULIFERA Augener.

Augener, 1918, p. 278, pl. v, figs. 99–101, text-fig. 27.

Occurrence.—South-West Africa (4).

ODONTOSYLLIS POLYCERA (Schmarda).

Augener, 1918, p. 283, pl. v, fig. 97, with synonymy.

Occurrence.—Table Bay (46); Luderitzbucht (4).

ODONTOSYLLIS CTENOSTOMA Claparède.

Fauvel, 1923, p. 277, fig. 104 *f-g*.

Occurrence.—Angola (4).

PTEROSYLLIS (AMBLYOSYLLIS) PICTA (Schmarda).

Cirrosyllis picta Schmarda, 1861, p. 76, pl. xxviii, fig. 225.

Amblyosyllis picta Augener, 1918, p. 291.

Occurrence.—Cape (46).

PIONOSYLLIS MALMGRENI McIntosh.

McIntosh, 1903, p. 35.

Occurrence.—False Bay (36).

PIONOSYLLIS EHLERSIAEFORMIS Augener.

Augener, 1913, p. 225, pl. iii, fig. 32, text-fig. 31.

Occurrence.—Swakopmund (4).

EUSYLLIS BLOMSTRANDI Malmgren.

Fauvel, 1923, p. 293, fig. 112 *h-m*.

Occurrence.—Angola (21).

GRUBEA RHOPALOPHORA Ehlers.

Augener, 1918, p. 295, pl. iv, fig. 94.

Occurrence.—South-West Africa (4).

OPISTHOSYLLIS ANKLYOCHAETA Fauvel.

Fauvel, 1921, p. 5, fig. 1.

Occurrence.—Madagascar (20).

SPHAEROSYLLIS SUBLAEVIS Ehlers.

Ehlers, 1913, p. 482, pl. xxxii, figs. 10–15.

Occurrence.—False Bay (17).

SPHAEROSYLLIS SEMIVERRUCOSA Ehlers.

Ehlers, 1913, p. 483, pl. xxxii, figs. 5–9.

Occurrence.—South-West Africa (17).

SPHAEROSYLLIS PERSPICAX Ehlers.

Ehlers, 1908, p. 66, pl. vi, figs. 1–3.

Occurrence.—South-West Africa (4).

EXOgone HETEROSETOSA McIntosh.

McIntosh, 1885, p. 205, pl. xxxiii, figs. 15–16, pl. xxxiv *a*, fig. 11.

Occurrence.—Round South Africa (4, 17, 19).

AUTOLYTUS PROLIFER (O. F. Müller).

Fauvel, 1923, p. 311, fig. 119.

Occurrence.—False Bay (18, 36).

? *AUTOLYTUS PICTUS* (Ehlers).

Fauvel, 1923, p. 315, fig. 121 *a-f*.

From plankton samples taken in False Bay, October 1930. Two specimens. Length 4 mm., number of segments 52.

Remarks.—Both specimens are of the *Polybostrichus* form with 6 anterior, 31 natatory, and 15 posterior segments. The bristles of the anterior segments resemble those of *A. pictus*, but until the asexual phase of this species has been recorded from this region, the correctness of this diagnosis must be accepted with caution.

Three other *Polybostrichus* forms occurred in the plankton samples, the largest of which had no unmodified parapodia at all. The feet of all the 23 segments were natatory, though the first pair were smaller than the rest and were directed forwards. Posteriorly there were a pair of very large anal cirri. The other two specimens were very small and obviously immature.

Occurrence.—False Bay (*).

AUTOLYTUS INERMIS Saint-Joseph.

Fauvel, 1923, p. 322, fig. 123 *h-k*.

Occurrence.—False Bay (17).

AUTOLYTUS TUBERCULATUS (Schmarda).

Augener, 1918, p. 307, with synonymy.

Occurrence.—Cape (46).

AUTOLYTUS BONDEI, sp. n.

Collected at St. James, January 1931, from between the tide-marks. Two specimens. Length 12 mm., breadth 2 mm., number of segments 54.

Diagnosis.—Eyes large, almost fused on each side. Median tentacles three times length of prostomium. Proventricule large and ovoid. Trepang with forty teeth of three different sizes arranged alternately in a series of large, medium, small, medium, large.

Description.—The body is short, the segments broad, ventrally flattened and dorsally curved. The colour in spirit is yellowish, and eggs are visible through the integuments of one specimen.

The prostomium is rounded, broader than long, and possesses four large red-brown eyes, of which the anterior pair are the larger. The eyes on each side of the head are almost fused. The palpi are short, partially fused, and bent ventrally. The tentacles are slightly club-shaped and non-articulated. The median, which is about three times the length of the prostomium, is a little longer than the laterals, but is itself shorter than the anterior cirri. The pharynx is long, S-shaped, and the proventricule is large and oval. There are ten large, ten small, and twenty intermediate sized teeth on the trepang in an alternate series of large, medium, small, medium, large, etc. The large teeth are twice the size of the small teeth.

The dorsal cirri are similar to the tentacles and are apparently smooth, but the preservation is not good enough to certify this point. Bristles are of the usual type. The top of the shaft is swollen and the articulated portion has a long neck and a short blade with two teeth; the second tooth is larger and blunter than the terminal one.

A *Polybostrichus* form was taken in the plankton samples with similar bristles in the anterior segments. It has 3 anterior and 23 natatory segments.

Remarks.—The form of the trepang distinguishes this from other species of *Autolytus*. In most there are only two types of teeth, large and small;

here the intermediate size is regularly present. This species is dedicated to Dr. C. von Bonde, to whose help I am indebted.

Occurrence.—False Bay (*).

MYRIANIDA PHYLLOCERA Augener.

Augener, 1918, p. 301, pl. iv, figs. 87–9, text-fig. 30.

Occurrence.—Luderitzbucht (4).

NEREIDAE.

LYCASTRIS QUADRICEPS Gay.

Augener, 1918, p. 214, pl. ii, fig. 35, pl. iii, fig. 68, text-fig. 17.

Occurrence.—Luderitzbucht (4).

NEREIS SUCCINEA (Leuckart).

Fauvel, 1923, p. 346, fig. 135 *f–m*, with synonymy.

Occurrence.—Cape Point to Algoa Bay (14, 17).

NEREIS UNIFASCIATA Willey.

Willey, 1905, p. 271, pl. iv, figs. 85–8.

Occurrence.—Madagascar (20).

NEREIS KAUDERNI Fauvel.

Fauvel, 1921, p. 8, pl. i, figs. 1–7.

Occurrence.—Madagascar (20).

NEREIS FALSA Quatrefages.

Fauvel, 1923, p. 337, fig. 129 *e–m*, with synonymy.

Occurrence.—Round South Africa (4, 19, 41).

NEREIS OPERTA (Stimpson).

Mastigonereis operta Willey, 1904, p. 261, pl. xiii, figs. 11, 12, pl. 14, figs. 7–8 *b*.

Nereis polyodonta, (Schmarda); Augener, 1918, p. 187.

Collected between the tide-marks at St. James and Durban. Fairly common. Length up to 55 mm., breadth 5 mm., number of segments 105.

Diagnosis.—Basal ring of paragnathi very broad ventrally with larger points near the maxillary ring (see text-fig. 5 *b*). Posterior parapodia with long dorsal ligules and short dorsal cirri (text-fig. 5 *c*).

Remarks.—Augener states that Stimpson's description is insufficient for diagnosis. This is true, but the same applies to Schmarda's description of *Mastigonereis polyodonta*. Since a sufficient description of Stimpson's species was first given by Willey in 1904, this name is here retained. Ehlers, 1913, p. 496, gives *Nereis operta* as a synonym of *Nereis (Platynereis) dumerilii*. The very young examples he described were without paragnathi, so it is impossible

to tell to which species they really belong. In older forms, where the paragnathi are present, these two species are immediately distinguishable.

Occurrence.—Round South Africa.

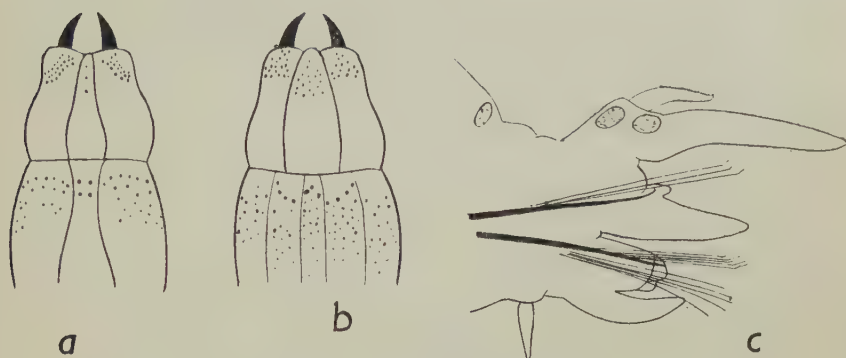


FIG. 5.—*Nereis aperta* (Stimpson).

a, dorsal; *b*, ventral paragnathi; *c*, posterior foot.

NEREIS WILLEIYI, nom. nov.

Nereis (*Neanthes*) *capensis* Willey, 1904, p. 261, pl. xiii, fig. 10, pl. xiv, figs. 9-10.

Collected between the tide-marks at St. James. Twelve specimens. Length up to 37 mm., breadth 3 mm., number of segments 68.

Diagnosis.—Palpophores massive, antennae short; tentacles reach to sixth or eighth setiger. Paragnathi with (i) a single point; (ii) and (iv) oblique

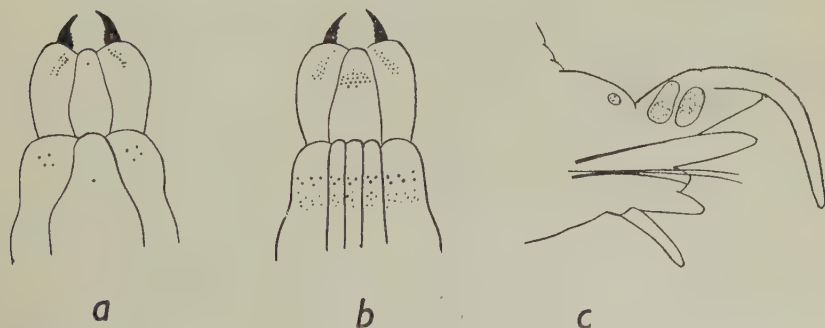


FIG. 6.—*Nereis willeyi*, nom. nov.

a, dorsal; *b*, ventral paragnathi; posterior foot.

rows; (iii) a crescentric group. On the basal ring (v) is a single point, sometimes missing; (vi) a prominent group of 4-8 points in a rosette; (vii) and (viii) a double row of larger and smaller points (see text-fig. 6 *a* & *b*). Posterior feet with very long dorsal cirri (see text-fig. 6 *c*).

Remarks.—This species approaches *Nereis succinea* in the character of its paragnathi, but is easily distinguished by the length of its dorsal cirri. Juvenile forms bear transverse bands of pigment, but in the adult the colour is brown, fading posteriorly; Willey's examples were dark green anteriorly.

The name *Nereis capensis* has been changed, as the specific name *capensis* is already occupied by Kinberg's *Arcte capensis*, described in 1865, and re-described by Monro as *Nereis (Perinereis) capensis*.

Occurrence.—Table Bay (47); False Bay (*).

NEREIS AGNESIAE Augener.

Augener, 1918, p. 194, pl. iii, figs. 69–71, pl. iv, figs. 76, 77, text-fig. 14

Occurrence.—Swakopmund (4).

DENDRONEREIS ARBORIFERA Peters.

Fauvel, 1919, p. 399, pl. xv, figs. 5–8.

Occurrence.—Mosambique (43); Madagascar (19).

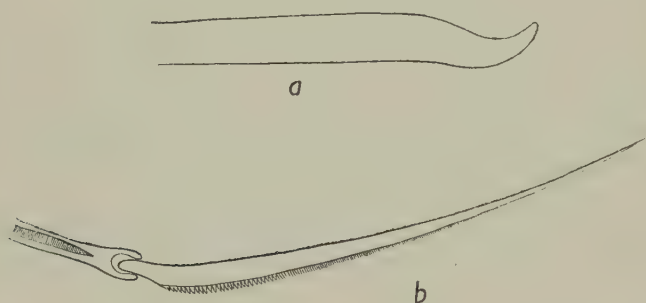


FIG. 7.—*a*, *Ceratonereis erythraensis* Fauvel. Simple giant bristle from posterior foot.
b, *Perinereis falsovariegata* Monro. Homomorph spiniger.

NEREIS (CERATONEREIS) ERYTHRAEENSIS Fauvel.

Fauvel, 1919, p. 407, pl. xvi, figs. 26–30 & 42–7.

Collected between the tide-marks at Durban. Three specimens. Length up to 95 mm., breadth 2 mm., number of segments 155.

Diagnosis.—Body extremely long and slender. Prostomium longer than broad, the longest tentacle 2–3 times length of prostomium. Palpophores short and stout. Eyes 4, large. All groups of paragnathi on basal ring absent, those on maxillary ring all present. Dorsal cirri longer than dorsal ligules. No falcigers on anterior feet; posterior feet with very small heteromorph falcigers and a large aciculate bristle curved at the tip (fig. 7 *a*).

Remarks.—This species was first described from Madagascar. The specimens from Durban have shorter tentacles and are without falcigers in the anterior feet. The simple curved aciculate bristles are unique in this genus, though also found in two species of *Platynereis*.

Occurrence.—Durban (*); Madagascar (19).

NEREIS (CERATONEREIS) HIRCINICOLA (Eisig).

Fauvel, 1923, p. 350, fig. 139 *g-n*, with synonymy.

Occurrence.—Madagascar (19).

NEREIS (CERATONEREIS) PACHYCHAETA Fauvel.

Fauvel, 1919, p. 403, pl. xv, figs. 22–5, text-fig. 8.

Occurrence.—Madagascar (19).

NEREIS (CERATONEREIS) MIRABILIS Kinberg.

Gravier, 1901, p. 172, pl. ii, fig. 42.

Occurrence.—Madagascar (19).

NEREIS (CERATONEREIS) COSTAE Grube.

Fauvel, 1923, p. 349, fig. 136 *a-f*.

Occurrence.—Madagascar (19).

NEREIS (PERINEREIS) VARIEGATA Grube.

McIntosh, 1903, p. 37, pl. i, figs. 6–10, pl. ii, figs. 11, 12.

Perinereis mendax (Stimpson); Willey, 1904, p. 262, pl. xiii, fig. 13, pl. xiv, figs. 3–6.

Collected between the tide-marks at St. James, Port Alfred, East London, Umkomaas (Natal), Durban. Specimens numerous. Length up to 150 mm., breadth 10 mm., number of segments 92.

Diagnosis.—Paragnathi with (i) a single point; (v) a single point; (vi) a single bar. Other groups variable. Dorsal ligules of posterior feet expanded and flattened, with short dorsal cirri at the apices.

Remarks.—It was found that no reliance could be placed on the exact position or number of points on the paragnathal groups other than those mentioned. Their position and number agree with those described by McIntosh, but from specimen to specimen there is considerable variation.

These worms were found in the interstices of barnacle colonies, under tunicates and the holdfasts of Algae, and in sandy mud. Large specimens are green dorsally, but the largest are often blue.

Occurrence.—Round South Africa.

NEREIS (PERINEREIS) FALSOVARIEGATA Monro.

Monro, 1933, p. 492, figs. 4–7.

Collected at St. James between the tide-marks. Four specimens. Length up to 21 mm., breadth 2 mm., number of segments 54.

Diagnosis.—Very similar to *P. variegata*, but colour brown, body smaller. Dorsal ligules of posterior feet not expanded, dorsal cirri long. Blades of ventral homogomph spinigers with about ten coarse teeth basally (text-fig. 7 *b*).

Remarks.—These specimens have been compared with examples of *Perinereis variegata* of the same size and from the same locality, and the differences remain constant. The bars on group (vi) are very short, and at first sight this species was thought to belong to the genus *Nereis*.

Occurrence.—False Bay (*); Stil Bay (42).

NEREIS (PERINEREIS) CULTIFERA Grube.

Fauvel, 1923, p. 352, fig. 137 *a-l*.

Collected between the tide-marks at Port Alfred by Mr. J. Dick. One specimen. Length 90 mm., breadth 3 mm., number of segments 112.

Remarks.—This species has not been recorded from South Africa before. The single example differs slightly from the European form, the three paragnathi on group (v.) being in a transverse line instead of a triangle; also the tentacles are shorter and the dorsal ligules of the posterior feet are longer.

Occurrence.—Port Alfred (*).

NEREIS (PERINEREIS) ANOMALA Gravier.

Gravier, 1901, p. 191, figs. 194–202, pl. xi, figs. 50–2.

Occurrence.—Madagascar (20).

NEREIS (PERINEREIS) CAPENSIS (Kinberg).

Monro, 1933, p. 495, figs. 7–11, with synonymy.

Collected at Durban and Umkomaas (Natal) between the tide-marks. Four specimens. Length up to 80 mm., breadth 6 mm., number of segments 76.

Diagnosis.—Proboscis (text-fig. 8 *a* & *b*) with (i) 2–3 points in a line; (v) missing; (vi) a single bar. Other groups normal. Palpophores massive. Tentacles short, two and a half times the length of prostomium. Eyes large. Dorsal cirri long.

Remarks.—Monro has already described the affinities of this species and its relationship with *P. cavifrons* Ehlers.

Two heteronereid specimens were obtained from Durban in October. In these the first modified foot is the 19th (see text-fig. 8 *c*).

Occurrence.—Table Bay to Durban (34, 42, *).

NEREIS (PERINEREIS) NUNTIA Savigny var. **VALLATA** (Grube).

Neanthes latipalpa typica (Schmarda); Willey, 1904, p. 260, pl. xiii, fig. 9, pl. xiv, figs. 1–2 *b*.

Collected between the tide-marks at St. James and East London. Length up to 63 mm., breadth 3 mm., number of segments 85.

Diagnosis.—Body long and slender; paragnathi with (i) 1–3 points in a line; (v) a single point forming the centre of twenty-three short transverse bars across the dorsal surface of the basal ring. Dorsal cirri about equal to dorsal ligules.

Remarks.—Fauvel, 1919, p. 415, gives a useful summary of the different varieties of this species. The longest tentacles of the specimens from St. James were less than four times the length of the prostomium, while those of the specimen from East London were between five and six times the length of the prostomium. In all the dorsal cirri were longer than the dorsal ligules, in which character they resemble the variety *brevicirris* Grube.

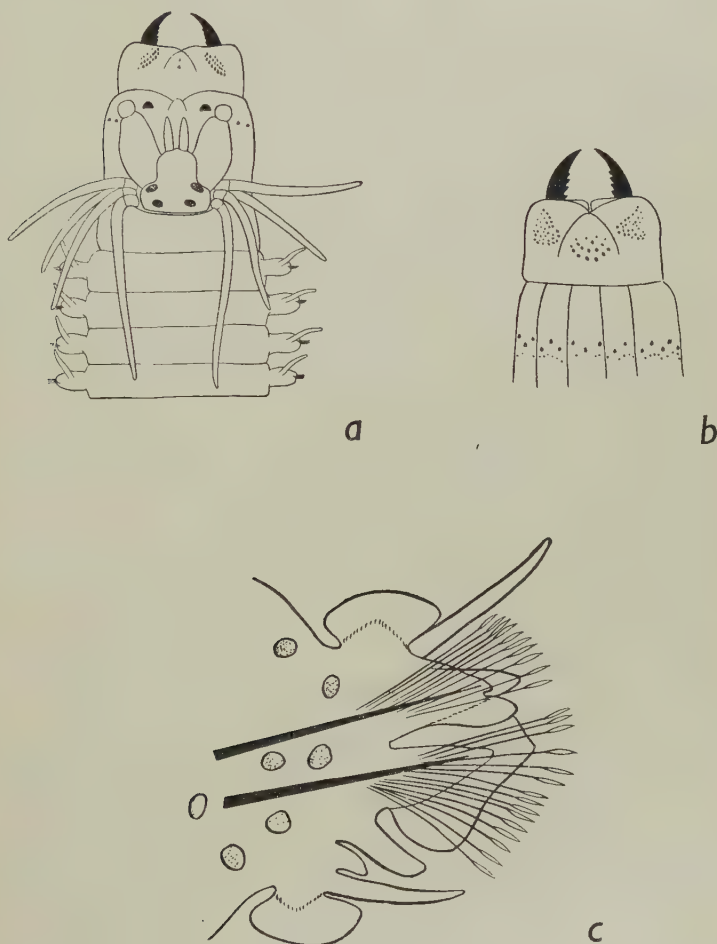
The specimens from St. James were found in moist sand at the high tide-mark, being the only Polychaets obtained from this level.

Occurrence.—Round South Africa.

NEREIS (PERINEREIS) NUNTIA var. MAJUNGAENSIS Fauvel.

Fauvel, 1921, p. 11.

Occurrence.—Madagascar (20).

FIG. 8.—*Perinereis capensis* (Kinberg).*a*, head; *b*, ventral paragnathi; *c*, 20th foot of an epitokous form.

NEREIS (PLATYNEREIS) DUMERILLI (Andouin & M.-Edwards) var. STRIATA (Schmarda).

Platynereis striata (Schmarda); Willey, 1904, p. 262, pl. xiii, fig. 14, pl. xiv, figs. 11, 12, 12 *a*.*Nereis* (*Mastigonereis*) *striata* Schmarda; McIntosh, 1924, p. 43, pl. vi, figs. 1, 2.*Nereis* (*Platynereis*) *australis* (Schmarda); Augener, 1913, p. 182, with synonymy.

Collected between the tide-marks at St. James, East London, and Durban.

Specimens common. Length of Durban specimens up to 43 mm., breadth 3.5 mm., number of segments 82.

Diagnosis.—Similar to *Pl. dumerilii*, but differing in the following characters: Prostomium almost rounded; eyes very large, in largest examples covering most of prostomium and provided with cuticular lenses. Posterior segments pigmented, giving a barred appearance. Tips of dorsal homogomph spinigers of anterior parapodia sharply curved.

Remarks.—In young specimens the eyes are without lenses and smaller, and the striped appearance of the posterior region is more marked.

Willey gives good figures of the head, parapodia, and bristles, but has apparently missed the dorsal homogomph falcigers of the posterior feet. It is somewhat difficult to visualise the condition of the eyes of McIntosh's specimens from the coast of Portuguese East Africa, but, as in the specimen from Durban, they evidently occupy most of the surface of the prostomium. The interesting fact thus emerges that the specimens from the tropical localities have larger eyes than those further south. McIntosh also gives a minute description of the pigmentation. In describing an example from New Zealand, Augener reviews Schmarda's original species, showing that *N. striata* and *N. quadridentata* are synonymous. The name var. *striata* is here retained, because it is the most descriptive and because the first sufficient description of the species was given by Willey under that name.

Platynereis dumerilii has been described from False Bay by Ehlers, 1913. His specimens were very small, but he remarks on the pigmentation of the posterior region. Monro's specimens from False Bay and Fauvel's specimens from Madagascar are not described †.

Occurrence.—Round South Africa.

NEREIS (PLATYNEREIS) HEWITTI, sp. n.

Collected between the tide-marks on Algae at Port Alfred, September 1929. One specimen. Length 16 mm., breadth (including parapodia) 2.5 mm., number of segments 60.

Diagnosis.—Paragnathi as in *Pl. dumerilii*; prostomium oval, longer than broad; palpophores short and swollen; antennae and tentacles long. Dorsal cirri long, dorsal ligules short and rounded in all feet. Dorsal homogomph falcigers characteristic, absent from first two feet, posteriorly numerous.

Description.—The single specimen found was small, tapered posteriorly, and of a general dull green colour. There are, however, pigmented areas on the head, feet, dorsum, and ventral surface. The banded effect found in *Pl. dumerilii* var. *striata* is not evident here, as the general colour is much darker.

The prostomium (text-fig. 9a) is oval, longer than broad, and the eyes are large and brown. On the anterior margin of the prostomium there are three prominent pigment spots in a transverse row. The palpophores are short,

† Horst describes an epitokous specimen in which the first heteronereid foot is the 16th.

stout, and pigmented distally, the palpi large and globular. The antennae extend further than the palpi and are about the same length as the prostomium. The tentacles are long, measuring four or five times the length of the prostomium

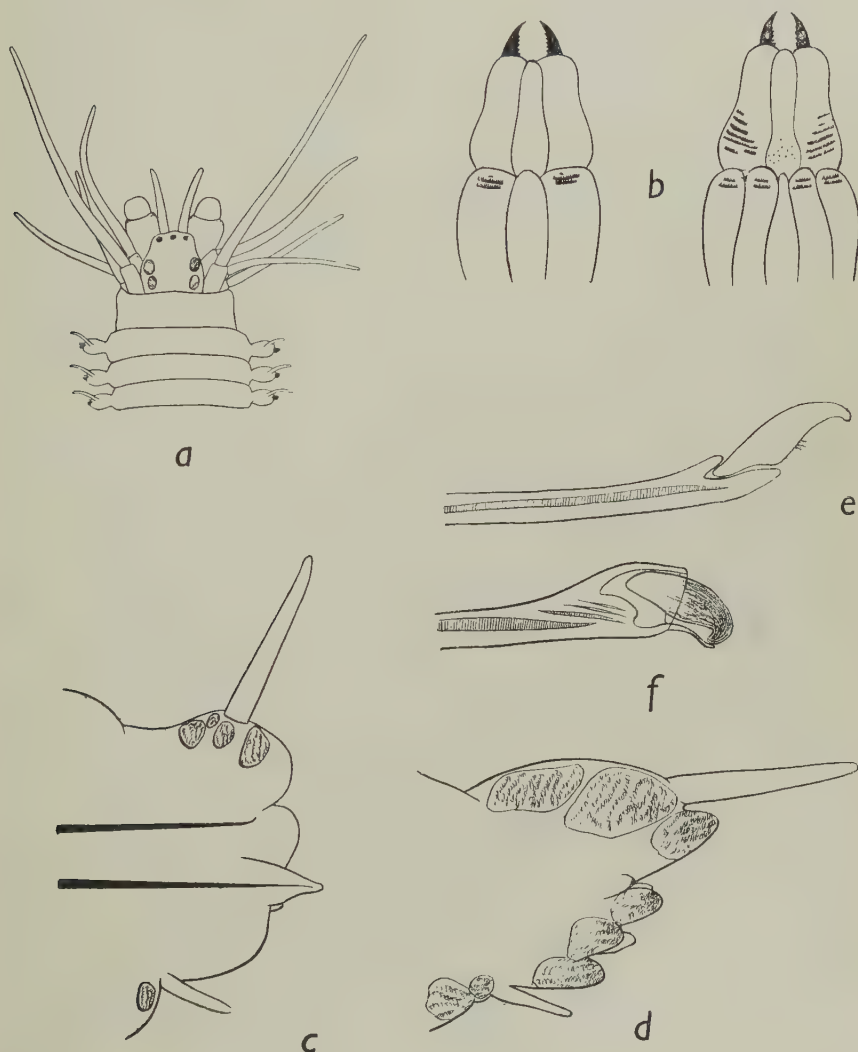


FIG. 9.—*Platynereis hewitti*, sp. n.

a, head; b, dorsal and ventral paragnath; c, anterior foot; d, posterior foot; e, heterogomph falciger; f, homogomph falciger.

and reaching back to the sixth or eighth setiger. The paragnathi are represented by comb-like bars similar to those of *Pl. dumerilii*, though more strongly marked. Groups (i), (ii), and (v) are absent. (iii) a scattered group of

short bars; (iv) is represented by several long parallel rows; (vi) has two to three curved rows, and on the ventral surface of the basal ring there are five short rows (see text-fig. 9 b).

The ligules of the anterior feet are short, rounded, and pigmented with the exception of the inferior setigerous lobe which is prominent, pointed, and colourless (text-fig. 9 c). The dorsal cirri are much longer than the dorsal ligules in all segments. Though the lobes project further in the posterior region, they are still rounded and pigmented. All feet are biramous. In the first two there are a few homogomph spinigers only in the dorsal bundle, and the ventral bundle is made up of a number of heterogomph falcigers with the apices like short broad-bladed spinigers. True heterogomph spinigers are absent. In the fourth foot one or two homogomph falcigers appear in the dorsal bundle, and a like number of homogomph spinigers appear in the superior part of the ventral bundle. In the eighth foot heterogomph falcigers are present in the ventral group and these bristles now have normal apices. The arrangement is as follows :—Dorsal bundle : homogomph spinigers and homogomph falcigers in equal numbers. Ventral group : superiorly homogomph spinigers and heterogomph falcigers; inferiorly, heterogomph falcigers only. The homogomph falcigers have pigmented apices which are characteristically short and broad (text-fig. 9 f). The spinigers have normal blades with slightly curved tips. The heterogomph falcigers are similar to those of *Pl. dumerilii*.

In the posterior feet (40th foot), the type of bristles and their arrangement remains unaltered, but the number of spinigers decreases. Thus the dorsal bundle consists mainly of homogomph falcigers, while the ventral bundle consists of heterogomph falcigers. This preponderance of falcigers over spinigers in the dorsal bundle of this species is in marked contrast with the condition in other members of the genus.

In anterior feet the acicula are black, in the posterior feet they are colourless.

Remarks.—It is well known that the number of falcigers increases in the posterior feet throughout the genus *Nereis*. In *Platynereis dumerilii* the homogomph falcigers begin about the middle of the body and increase slightly in numbers in the posterior region, but the number of falcigers never exceeds the number of spinigers. In this case the 50th foot bears seven homogomph falcigers and two dorsal homogomph spinigers. In the anterior feet true heterogomph spinigers are absent, though replaced in the first four feet by modified falcigers with long sword-like blades.

Occurrence.—Port Alfred (*).

NEPHTHYDIDAE.

NEPHTHYS HOMBERGI Audouin & M.-Edwards.

Fauvel, 1923, p. 367, fig. 143 a-d.

Occurrence.—Round South Africa.

NEPHTHYS TULEARENSIS Fauvel.

Fauvel, 1919, p. 422, pl. xvi, figs. 31-9.

Occurrence.—Madagascar (19).

NEPHTHYS AMBRIZETTANA Augener.

Augener, 1918, p. 166, pl. ii, fig. 13, pl. iii, figs. 60, 61.

Occurrence.—Angola (4).

NEPHTHYS HYSTRICIS McIntosh.

Fauvel, 1923, p. 373, fig. 146 a-e.

Collected by the s.s. *Pickle* off the coast of Portuguese East Africa. One specimen. Length 75 mm., breadth 3 mm., number of segments 100.

Remarks.—This species has not been recorded from South Africa before. It agrees very closely with the European form.

Occurrence.—Mosambique (*).

SPHAERODORIDAE.

EPHESIA GRACILIS Rathke.

Fauvel, 1923, p. 377, fig. 148 a-f.

Occurrence.—Francis Bay (14).

GLYCERIDAE.

GLYCERA SUBAENEA Grube.

Fauvel, 1919, p. 425, pl. xvi, figs. 48-51.

Occurrence.—Madagascar (19).

GLYCERA CONVOLUTA Keferstein.

Fauvel, 1923, p. 383, fig. 150 a-h.

Glycera africana Arwidsson Willey, 1904, p. 260.

Occurrence.—Round South Africa.

GLYCERA CONVOLUTA var. CAPENSIS Monro.

Monro, 1933, p. 499, fig. 12.

Glycera alba McIntosh (non Rathke), 1924, p. 68.

Collected in sand between the tide-marks at St. James. One specimen. Length 60 mm., breadth 2 mm., number of segments 130.

Diagnosis.—Similar to *Glycera convoluta*, but with non-retractile branchiae commencing on the 21st to 24th foot, and reaching a maximum of 2-3 filaments. Posterior segments with branchiae arising from base of foot. Parapodia long, lobes conical, unequal.

Remarks.—As suggested by Monro, McIntosh's specimens must belong to this species. The present specimen had mostly bifid branchiae, and the whole gill is absent from the last few feet.

Occurrence.—False Bay to Mosambique (38, 42, *).

GLYCERA ROUXII Audouin & M.-Edwards.

Fauvel, 1923, p. 389, fig. 153 *a-c*, with synonymy.

Occurrence.—Agulhas Bank, in 123 fathoms (38).

GLYCERA KRAUSSI Stimpson.

Ehlers, 1908, p. 103.

Occurrence.—False Bay to Algoa Bay (17, 14).

GONIADA MACULATA Oersted.

Fauvel, 1923, p. 392, fig. 154 *a-g*.

Collected between the tide-marks at St. James. One specimen. Length 48 mm., breadth 1.0 mm., number of segments 150.

Remarks.—No representative of this genus has been recorded from South Africa before. There are, however, no important differences between this and the European form. The general colour is dark brown and no eyes could be distinguished. There are eight annulations on the prostomium, and the feet are biramous from the 16th segment.

Occurrence.—False Bay (*).

EUNICIDAE.

EUNICE VITTATA (Delle Chiaje).

Fauvel, 1923, p. 404, fig. 158 *h-m*.

Occurrence.—Round South Africa (21, 38).

EUNICE APHRODITOIS (Pallas).

Eunice rousseaui Quatrefages; Fauvel, 1923, p. 403, fig. 158 *a-g*.

Collected between the tide-marks at Fish River Point by Dr. Smith, March 1929. One specimen. Length 230 mm., breadth 11 mm., number of segments 286.

Remarks.—The characteristics of the dental apparatus, tentacles, branchiae, colouring, and large size agree perfectly in the two species. The small differences in the shape of the setæ figured by Marenzeller, 1887, pl. i, fig. 3, are not in themselves sufficient to separate them.

Occurrence.—Round South Africa.

EUNICE GRUBEI Gravier.

Crossland, 1904, p. 288.

Occurrence.—Agulhas Bank (14).

EUNICE COCCINEA Grube.

Crossland, 1904, p. 297, pl. xx, figs. 6, 7.

Occurrence.—Mosambique (38); Madagascar (19).

EUNICE MURRAYI McIntosh.

McIntosh, 1885, p. 288, pl. xxxix, figs. 7-8, pl. xx a, figs. 19, 20; Crossland, 1904, p. 310.

Collected between the tide-marks at Umkomaas (Natal). Two specimens. Length 80 mm., breadth 4.5 mm., number of segments 112.

Diagnosis.—Jaws asymmetrical, tentacles long, deeply annulated; median about three times length of prostomium. Gills arise on the third to sixth foot, increase to a maximum of fifteen filaments, but confined to anterior region. Dorsal bristles simple and curved, ventral falcigers with two teeth. Three to five acicula and curved, each with a guard and three teeth.

Remarks.—Crossland says that the branchiae usually end on the 45th foot, and in some cases are continued to the 55th. In the present specimen the last gill is on the 60th foot.

This species, as well as *E. australis* Quatrefages, with which, according to Augener, it is identical, has been recorded from South Africa before. *E. australis* has been recorded by Ehlers, 1908, and *E. murrayi* by McIntosh and Monro.

Occurrence.—Table Bay to Natal (35, 41, *).

EUNICE ANTENNATA Savigny.

Crossland, 1904, p. 312, pl. xxii, figs. 1-7, text-figs. 56-60.

Collected between the tide-marks at Umkomaas (Natal), October 1930. One specimen. Length (incomplete) 96 mm., breadth 6.5 mm., number of segments 97.

Diagnosis.—Similar to *E. murrayi*, but with branchiae continuing over whole body. Tentacles longer, not so deeply notched.

Remarks.—The body of the present specimen is incomplete posteriorly, but the gills continue undiminished in size on the 97th foot. The specimen was a female, and small unripe eggs were found in its body.

Occurrence.—Natal (*); Madagascar (19).

EUNICE INDICA Kinberg.

Crossland, 1904, p. 318, pl. xxi, figs. 9-12.

Occurrence.—False Bay (17); Madagascar (19).

EUNICE SICILIENSIS Grube.

Fauvel, 1923, p. 405, fig. 159 e-m.

Occurrence.—Round South Africa (19, 37, 41).

EUNICE AFRA Peters.

Crossland, 1904, p. 289, pl. xx, figs. 1-5; Fauvel, 1919, p. 374, with synonymy.

Occurrence.—Mosambique (43); Madagascar (19).

EUNICE TORQUATA Quatrefages.

Fauvel, 1923, p. 401, fig. 157 h-o, with synonymy.

Occurrence; Angola (4).

EUNICE AUSTRALIS Quatrefages.

Ehlers, 'Neuseelandische Anneliden', 1904, p. 30.

Occurrence.—Agulhas Bank (14); Francis Bay (14).

EUNICE SAVIGNYI Grube.

Ehlers, 1908, p. 88, pl. xi, figs. 7-13.

Occurrence.—Agulhas Bank (14).

EUNICE TUBIFEX Crossland.

Crossland, 1904, p. 303, pl. xxi, figs. 1-8.

Eunice depressa Schmarda; McIntosh, 1924, p. 48, pl. vii, figs. 5-6.

Occurrence.—Durban (38).

EUNICE FLORIDANA Pourtales.

Fauvel, 1923, p. 402, fig. 157 a-g.

Occurrence.—Mosambique (38).

EUNICE FILAMENTOSA Grube.

Augener, 1918, p. 324, with synonymy.

Occurrence.—Angola (4); Stil Bay (42).

MARPHYSA SANGUINEA (Montagu).

Fauvel, 1923, p. 408, fig. 161 a-h.

Marphysa furcellata Crossland, 1903, p. 141.

Collected between the tide-marks at St. James and Port Alfred. Specimens abundant. Length up to 130 mm., breadth 11 mm., number of segments 205.

Remarks.—In one specimen otherwise typical the dental formula may be expressed as:—1+1; 4+4; 5+0; $3+\frac{7}{3}$. The right crescentic plate has seven normal teeth and below them three smaller teeth in parallel series.

Marphysa sanguinea has already been recorded from the Cape by McIntosh, 1903, and Willey, 1904. There is no essential difference between this and Crossland's species *M. furcellata*.

Occurrence.—Round South Africa.

MARPHYSA AENEA Blanchard.

Marphysa corallina (Kinberg); Ehlers, 1901, p. 131, pl. xv, figs. 13-18.

Collected between the tide-marks at East London and Durban. Three specimens. Length 200 mm., breadth 8.5 mm., number of segments 256.

Remarks.—A useful key to the genus *Marphysa* is given by Crossland, 1903, p. 136. *Marphysa aenea* is characterised by its bifid prostomium, short tentacles, falcate compound setae, and 3-5 teeth on the great dental plates. The branchiae commence between the 30th and 40th segment and reach a maximum of seven filaments.

The Natal specimen differs from those collected at East London. The body is longer and more slender, being 260 mm. long, 6 mm. broad, and having

300 segments. The branchiae begin on the 30th setiger and the anterior segments are rounded and narrower than the rest.

Occurrence.—Madagascar (19); East London (*); Durban (*).

MARPHYSA MACINTOSHI Crossland.

Crossland, 1903, p. 137, pl. xiv, figs. 3-6, text-fig. 12.

Occurrence.—Mosambique (38).

MARPHYSA ADENENSIS Gravier.

Marphysa purcellana Willey, 1904, p. 263, pl. xiii, fig. 17.

Occurrence.—Table Bay (47).

MARPHYSA CAPENSIS (Schmarda).

Willey, 1904, p. 263, pl. xiii, fig. 16.

Occurrence.—Cape (46, 47).

MARPHYSA MOSSAMBICA (Peters).

Crossland, 1903, p. 139, pl. xv, figs. 7-10.

Occurrence.—Mosambique (43).

MARPHYSA DURBANENSIS, sp. n.

Collected between the tide-marks in Durban Bay and at Umkomaas (Natal). Two specimens. Length 380 mm., breadth 4 mm., number of segments 300.

Diagnosis.—Body very long and slender, almost rounded. Prostomium bifid. Tentacles longer than twice prostomium. Great dental plates with six to eight teeth. Branchiae commence on 28th to 33rd setiger reach a maximum of eight filaments, and extend over entire body. Bristles capillary and compound with very long knife-like blades.

Description.—The colour in spirit is an iridescent pale brown. The body is extremely long and uniformly slender, broadly oval in section, but the first 8-10 segments are narrowed and rounded. The last thirty segments decrease rapidly in size to the large anus. There are four large anal cirri, of which the superior pair are much the largest.

The prostomium is deeply bifid and the tapered median tentacle is a little longer than twice the prostomium, laterals shorter. The bases of the tentacles are ringed as mentioned by Crossland in his description of *Marphysa mossambica*, and the tentacles themselves are probably annulated, though the preservation of the specimens does not allow of exact description. The eyes are almost colourless. The dental plates are soft and brown, the formula being:—(i) 1+1; (ii) 6+7; (iii) 7+0; (iv) 3+7. In the specimen from Umkomaas the teeth are more numerous (i) 1+1; (ii) 6+8; (iii) 6+0; (iv) 4+8. The mandibles have long slender shafts, and their serrated cutting edges curve inward, the whole being marked with longitudinal parallel ridges.

The branchiae commence on the 28th to 33rd setiger as simple filaments, increase to a maximum of eight filaments on the 80th setiger, and continue

undiminished in size to the 50th segment from the anus. Between the 50th and 20th segment from the anus the filaments decrease in number and size, and then end. The gills never cover the dorsum. The lobes of the feet are small, the dorsal cirrus short and conical, and the ventral pad is not large (text-fig. 10). In the anterior region there are long simple bristles with fine, slightly curved tips, as well as fine brushes in the dorsal group and compound bristles with long slender blades ventrally. There are three black acicula. In the posterior region the brushes become more numerous, and there is a graded series from long forms with numerous fine teeth to short, stout forms with about six coarse teeth. This character is common in other species of the genus. In the ventral bundle the shafts of the compound bristles are often completely embedded in the parapodium, while the blades become longer and finer. These



FIG. 10.—*Marphysa durbanensis*, sp. n.

Parapodium and setae of 50th segment.

bristles are often broken, and there is a strong superficial resemblance to *Marphysa mossambica*, where all bristles are capillary, but are often broken off short.

Remarks.—This species belongs to the group including *M. simplex* Crossland and *M. acicularum* Webster. A fragment of a variety of the latter species described by McIntosh, 1924, from Portuguese East Africa shows many points of resemblance. The slenderness of the compound bristles is a striking feature, though not so strongly marked in McIntosh's specimen. The present species may be distinguished from the latter by the shorter tentacles, larger gills, and the character of the dental apparatus, as there are more teeth on the unpaired and crescentic plates. Crossland's species agrees with it in the general shape of the body, but the tentacles and the blades of the compound setae

of his species are shorter, the teeth on the great dental plates are fewer, and the number of filaments on the gills is less.

Occurrence.—Natal (*).

MARPHYSA ACICULARUM Webster, var.

McIntosh, 1924, p. 57, pl. vii, fig. 9.

Occurrence.—Mosambique (38).

LYSIDICE NINETTA Audouin & M.-Edwards.

Fauvel, 1923, p. 411, fig. 162 *a-g*.

Occurrence.—Angola (4).

LYSIDICE CAPENSIS Grube.

McIntosh, 1903, p. 40, pl. iii, fig. 13; Ehlers, 1908, p. 94, pl. xii, fig. 8.

Collected in muddy sand between the tide-marks at St. James and Port Alfred. Specimens common. Length up to 120 mm., breadth 7 mm., number of segments 295.

Diagnosis.—Related to *L. fallax* Ehlers, but differing in the structure of maxillae, figured by Ehlers, 1908, pl. xii, fig. 8. Dental formula :—(i) 1+1; (ii) 3+3; (iii) 1-2+0; (iv) 3+3-4. Tentacles short, cylindrical, distal half pale. Prostomium bifid and white.

Remarks.—Ehlers figures the great dental plate on the right side with two teeth. All the teeth are large and blunt, and the unpaired plate is almost fused with the crescentic plate on the left side. In life these worms are reddish brown in colour with numerous yellow and red specks anteriorly. The prostomium is yellowish above and white below. A specimen obtained from Port Alfred in September was swollen with eggs.

Occurrence.—Round South Africa.

NEMATONEREIS UNICORNIS (Grube).

Fauvel, 1923, p. 412, fig. 162 *h-n*.

Occurrence.—Madagascar (20).

ONUPHIS EMERITA Audouin & M.-Edwards.

Fauvel, 1923, p. 414, fig. 163.

Occurrence.—False Bay (41); Madagascar (19).

ONUPHIS QUADRICUSPIS Sars.

Fauvel, 1923, p. 418, fig. 165 *f-p*.

Occurrence.—N.W. of Cape Point (38).

ONUPHIS HOLOBRANCHIATA Marenzeller.

Crossland, 1903, p. 135, pl. xiv, fig. 2.

Occurrence.—False Bay (14).

DIOPATRA CUPREA Bosc.

Augener, 1918, p. 350, text-fig. 39.

Occurrence.—Round South Africa (4, 14, 41).

DIOPATRA NEAPOLITANA Delle Chiaje.

Fauvel, 1923, p. 419, fig. 166 *a-h*.

Diopatra near *viridis* Kinberg; McIntosh, 1924, p. 63.

Diopatra near *dentata* Kinberg; McIntosh, 1924, p. 65.

Diopatra near *braziliensis* Kinberg; McIntosh, 1924, p. 65.

Collected by the s.s. *Pickle* on the Agulhas Bank in 47 fathoms and off the coast of Portuguese East Africa.

Remarks.—In considering the specimens described by McIntosh it is to be noted that they all agree with *D. neapolitana* in general form and in the structure of the setæ, and differ only in the size of the branchiae. It is probable that these differences are due to age and local variation. Some authorities regard *D. cuprea* as identical with *D. neapolitana*; others again regard *D. cuprea* as the Southern form of the latter species. As the matter is still unsettled both species are given as recorded.

Occurrence.—(4, 19, 21, *).

DIOPATRA PUNCTIFERA Ehlers.

Ehlers, 1908, p. 79, pl. x, figs. 1-11; Monro, 1930, p. 124, fig. 44.

Occurrence.—Agulhas Bank (14); off Saldanha Bay (41).

DIOPATRA MUSSERAËNSIS Augener.

Augener, 1918, p. 347, pl. v, fig. 134, pl. vi, fig. 195, text-fig. 38.

Occurrence.—Angola (4).

EPIDIOPATRA HUFFERIANA Augener.

Augener, 1918, p. 355, pl. v, figs. 104-6, pl. vi, fig. 212, text-fig. 40.

Occurrence.—False Bay (41).

HYALINOECIA TUBICOLA (O. F. Müller).

Fauvel, 1923, p. 421, fig. 166 *i-q*.

Occurrence.—Round South Africa.

NICIDION near CINCTA Kinberg.

McIntosh, 1924, p. 59, pl. vii, figs. 10, 11.

Occurrence.—Durban (38).

AGLAURIDES FULGIDA (Savigny).

Agaurides erythræensis Gravier, 1900, p. 282, pl. xiv, figs. 99-103, text-figs. 154-159.

Occurrence.—Madagascar (19).

LUMBRICONEREIDAE.

LUMBRICONEREIS IMPATIENS Claparède.

Fauvel, 1923, p. 429, fig. 171 *a-i*.

Occurrence.—Swakopmund (4).

LUMBRICONEREIS CAVIFRONS Grube.

Lumbriconereis capensis Willey, 1904, p. 265.

Non *Lumbriconereis cavifrons* McIntosh, 1903, p. 50.

Occurrence.—False Bay (47); Madagascar (19).

LUMBRICONEREIS LATREILLI Audouin & M.-Edwards.

Fauvel, 1923, p. 431, fig. 171 *m-r*, with synonymy.

Occurrence.—Round South Africa (18, 20, 47).

LUMBRICONEREIS COCCINEA Renieri.

Fauvel, 1923, p. 432, fig. 172 *g-n*; Crossland, 1924, p. 32.

Occurrence.—South-West Africa (4); Cape (47).

LUMBRICONEREIS OCULATA Ehlers.

Ehlers, 1908, p. 96, pl. xiii, figs. 1-6.

Occurrence.—Francis Bay (14).

LUMBRICONEREIS ALBIDENTATA Ehlers.

Ehlers, 1908, p. 97, pl. xiii, figs. 7-13.

Occurrence.—False Bay (17); Agulhas Bank (14).

LUMBRICONEREIS TETRAURA (Schmarda).

Ehlers, 1901, p. 137, pl. xvii, figs. 1-10; McIntosh, 1903, p. 48, pl. iii, fig. 18.

Collected between the tide-marks at St. James, Port Alfred, and Fish River Point. Specimens numerous. Length up to 160 mm., breadth 2.5 mm., number of segments 272.

Diagnosis.—Body long with numerous segments; head conical, anterior segments not narrowed. Maxillae with very long slender supports; dental formula :—1+1; 2+2; 4-5+4-5. Wings of capillary bristles shorter and broader posteriorly, the basal part becoming dentate. Crotchets commence between 5th and 10th foot. Posterior feet with crotchets only.

Occurrence.—False Bay to East London (14, 35, 41).

LUMBRICONEREIS ALBIFRONS Crossland.

Crossland, 1924, p. 50, text-figs. 65-72, with synonymy.

Collected between the tide-marks at St. James. Specimens numerous. Length 26 mm., breadth 1.8 mm., number of segments 60.

Remarks.—A key to the Lumbriconereidae is given by Crossland, 1924, p. 2. This species is common in False Bay, living on the branches of Algae, Hydroids, and Polyzoans. It is immediately identifiable by its small size, uniform yellow body-colour, and white globular prostomium. The Cape form, first described by McIntosh, 1903, p. 50, as *Lumbriconereis cavifrons*, agrees with Crossland's description, with the exception that there are only 2-3 teeth on the second dental plate. McIntosh's fig. 21, pl. iii, is misleading in this respect, but is corrected in the text. This species is closely related with *L. sphaerocephala* Schmarda (Ehlers, 1904) from New Zealand.

Occurrence.—False Bay (37, *).

LUMBRICONEREIS HETEROPODA Marenzeller.

Crossland, 1924, p. 4, text-figs. 1-7.

Dredged by the s.s. *Africana* off Dassen Island. Four specimens. Also collected between the tide-marks at Durban. Two specimens. Length 200 mm., breadth 4 mm., number of segments 280.

Diagnosis.—Posterior lip of seta-sac especially in posterior segments prolonged into a finger-like process. No compound setae.

Remarks.—The colour in life is a rich golden brown. The habitat is fine sandy mud. This species is closely allied with *L. papillifera* Fauvel.

Occurrence.—Round South Africa (9, 19, *).

LUMBRICONEREIS PAPILLIFERA Fauvel.

Fauvel, 1919, p. 395, pl. xv, figs. 9-16.

Occurrence.—Madagascar (19).

LUMBRICONEREIS FLORIDANA Ehlers.

Ehlers, 1887, p. 103, pl. xxx, figs. 10-15; Augener, 1918, p. 366.

Occurrence.—Angola (4).

LUMBRICONEREIS DEBILIS Grube.

Crossland, 1924, p. 34, figs. 41-52.

Collected between the tide-marks at St. James. Two specimens. Length 20 mm., breadth 1.2 mm., number of segments 110.

Remarks.—This is a new record for the Cape. The diagnostic features are given by Crossland. This species resembles *L. albifrons* Crossland, differing mainly in the absence of compound setae.

Occurrence.—False Bay (*).

ARABELLA IRICOLOR (Montagu).

Fauvel, 1923, p. 438, fig. 175 a-h.

Arabella iricolor var. *caerulea* (Schmarda); McIntosh, 1903, p. 46, pl. iv, figs. 16-17.

Collected between the tide-marks at St. James and Port Alfred. Specimens numerous. Length up to 200 mm., breadth 2.5 mm., number of segments 300.

Remarks.—Monro, 1933, records *A. mutans* (Chamberlin) from the Cape, and a doubt has arisen as to whether the specimens of *A. iricolor* recorded from this region by various authors really refer to *A. mutans*, which is distinguished by the presence of hooded crotchets in the posterior region of the body. As in the European form described by Fauvel there are three groups of bristles in all feet. Each of the three groups arises from a different position in the parapodium. First, there is a group of five winged capillaries, in some of which the blade is sharply curved, in others only slightly curved. The sharply curved bristles are more numerous in the posterior region and the base of the blade is broad and serrated. Second, there is a group of three to four small, deeply embedded acicula; third, a group of five stout acicula, the tips of which narrow sharply and just project through the integuments. Some confusion has arisen

by the use of Crossland's term "acicular bristles," though further reference to his work has shown that these bristles are distinct from the large acicula and refer to Chamberlin's "hooded crotchets." The latter term allows of no confusion. These hooded crotchets were absent in these specimens, though in two cases regenerating winged bristles were seen which might be interpreted as such. By the kindness of Mr. Monro of the British Museum I was able to examine McIntosh's type specimen from Guernsey to see whether "hooded crotchets" were present. They were not. The same groups of bristles were present as in the South African form, but all types were more numerous. This may be accounted for by the larger size of McIntosh's specimen (400 mm.).

Occurrence.—Round South Africa.

ARABELLA MUTANS (Chamberlin).

Monro, 1933, p. 501, with synonymy.

Cenothrix mutans Chamberlin, 1919, p. 339, pl. lxi, figs. 1-9, pl. xliii, fig. 1.

Occurrence.—Stil Bay (42).

STAUROCEPHALIDAE.

STAUROCEPHALUS RUBROVITTATUS Grube.

Fauvel, 1923, p. 445, fig. 177 *a-l*.

Occurrence.—Angola (4).

STAUROCEPHALUS NEGLECTUS Fauvel.

Fauvel, 1923, p. 447, fig. 179 *i-q*.

Collected between the tide-marks at St. James. One specimen. Length 10 mm., breadth 1.2 mm., number of segments 70.

Remarks.—The specimen is typical, except that there are four eyes and the prostomium is rounded. The presence of the posterior pair of eyes is suggested by Monro, 1930, in his description of a specimen from Simonstown.

Occurrence.—False Bay (41, *).

STAUROCEPHALUS EGENUS (Ehlers).

Stauronereis egena Ehlers, 1913, p. 501, pl. xxxv, figs. 1-6.

Occurrence.—False Bay (17); South-West Africa (4).

STAUROCEPHALUS ANGOLANUS (Augener).

Stauronereis angolana Augener, 1918, p. 380, pl. v, figs. 132-3, pl. vi, fig. 217, text-fig. 46.

Occurrence.—Angola (4).

ARICIIDAE.

ARICIA BIORETI Fauvel.

Fauvel, 1919, p. 430, pl. xvi, figs. 52-6.

Occurrence.—Madagascar (19).

ARICIA FOETIDA Claparède var. *AUSTRALIS* Fauvel.

Fauvel, 1919, p. 429.

Occurrence.—Madagascar (19).

ARICIA ANGRAPEQUENSIS Augener.

Augener, 1918, p. 413, pl. vi, fig. 146, pl. vii, fig. 225, text-fig. 56.

Occurrence.—South-West Africa (4).

SCOLOPLOS ARMIGER (O. F. Muller).

Fauvel, 1927, p. 20, fig. 6 *k-q*.

Occurrence.—False Bay (41).

SCOLOPLOS MADAGASCARENSIS Fauvel.

Fauvel, 1919, p. 433, pl. xvii, figs. 81-6.

Occurrence.—Madagascar (19).

SCOLOPLOS JOHNSTONEI, sp. n.

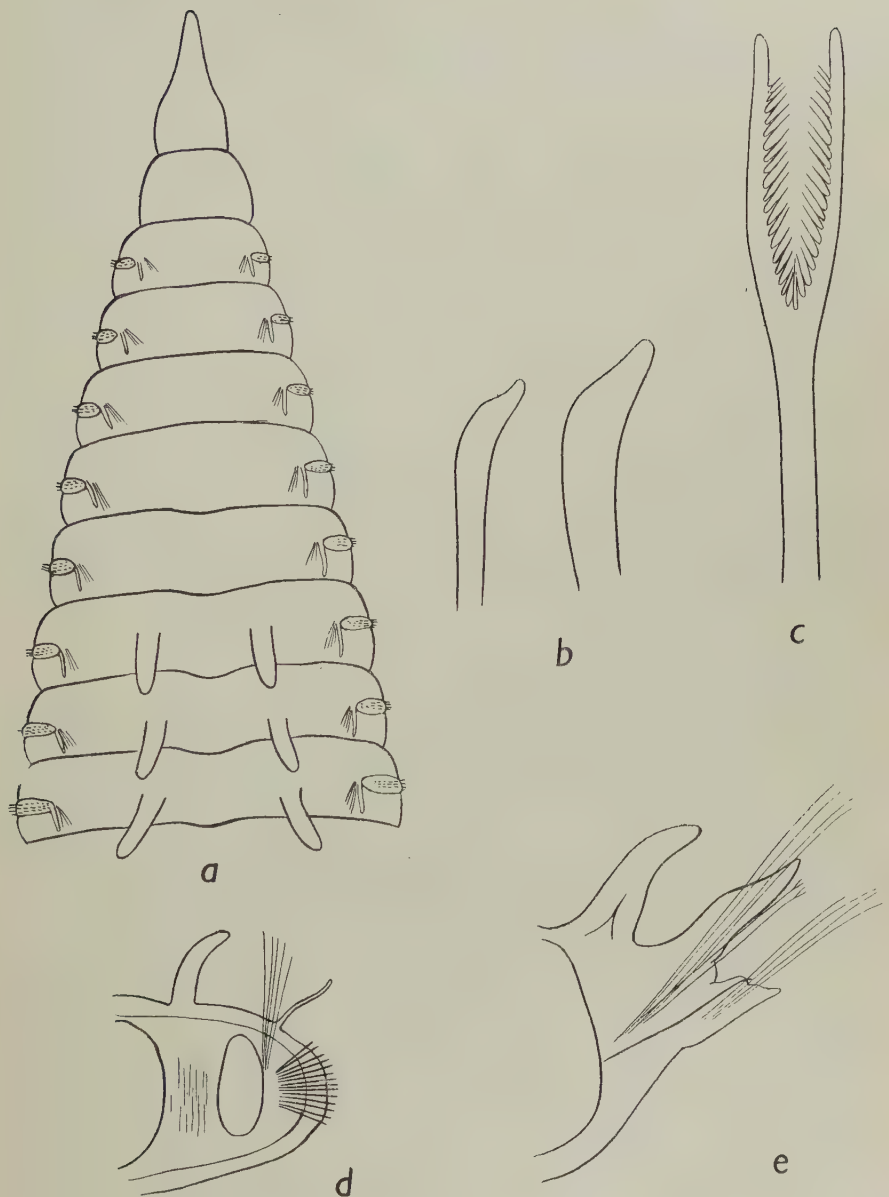
Collected in muddy sand between the tide-marks at St. James. Two specimens. Length up to 35 mm., breadth 1 mm., number of segments 180.

Diagnosis.—Prostomium sharply pointed; thoracic region of twenty-three setigers; branchiae from 6th setiger. Ventral rami of thoracic feet with three rows of crotchets, but without capillary bristles or papillae. Forked bristles of abdominal region with equal prongs.

Description.—The dark brown body is long and slender and divided into a thoracic region of twenty-three flattened and expanded setigers and a rounded abdominal region with larger branchiae and cirri. The prostomium is long, conical, and pointed. No eyes were seen, but this may be due to the general dark colour of the animal.

The thoracic region consists of twenty-three setigers (text-fig. 11 *a*). The branchiae which arise on the 6th setiger near the mid-dorsal groove are large conical organs, which increase in size posteriorly. The dorsal cirri are much more slender and arise just behind the dorsal bristle bundle, which is composed entirely of crenulate capillaries in this region. The ventral ramus of the thoracic foot (text-fig. 11 *d*) is lateral in position and is formed by a long ridge down the side of the segment. It bears three to four parallel rows of crotchets, with about twelve in each row, each curved at the tip (text-fig. 11 *b*). As in *S. madagascarensis* Fauvel there are no ventral papillae except on the last two segments of the thoracic region. On the 22nd and 23rd segments there are two small papillae posterior to the rows of crotchets, one at the top and one at the bottom of the setigerous ridge.

This species also differs from all others of the genus by the lack of capillary bristles in the ventral rami of the thoracic feet. In *S. madagascarensis* there are only a few, but in this species it is only the last thoracic segment that bears them, and even there only one small capillary is present.

FIG. 11.—*Scoloplos johnstonei*, sp. n.

a, head and anterior segments; *b*, anterior crotchets; *c*, bifurcate bristle;
d, anterior segment; *e*, posterior segment.

The two small papillae found on the last two thoracic feet are continued on the first few segments of the abdomen. The superior one forms the ventral ramus of the foot and carries the capillary bristles. The inferior one forms a gradually decreasing cirriform process below it and finally disappears on the 34th segment.

In the abdominal region the segments are rounded and the ventral ramus of the foot is dorso-lateral in position. Both the branchiae and the dorsal lobes of the feet increase in length (see text-fig. 11 *d*). In the dorsal bristle bundle, the capillaries become longer and at least two forked bristles appear with smooth shafts and equal prongs, which are plumulose on their inner edges (see text-fig. 11 *c*).

The ventral ramus of the foot is supported by a single long-shafted crotchet slightly curved at the tip. Besides this there is a bundle of capillaries which are less obviously crenulate than those of the dorsal group.

Remarks.—This species approaches *S. armiger* (Muller) in form and proportions. The branchiae, however, commence earlier, and the thoracic feet are without capillary bristles or papillae ventrally. This character is found to a less extent in *S. madagascarensis*. In the latter species the branchiae commence on the 21st or 22nd segment and are sometimes bifid. *S. kerguelensis* McIntosh shows no similarities, nor does *S. cylindrifer* Ehlers, the branchiae of which are as a rule bifid.

Occurrence.—False Bay (*).

NAINEREIS LAEVIGATA (Grube).

Fauvel, 1927, p. 22, fig. 7 *a-l*, with synonymy.

Collected in sandy mud between the tide-marks at St. James. Specimens numerous. Lengths up to 105 mm., breadth (of thorax) 6 mm., number of segments 360.

Remarks.—These worms are coloured red-brown when alive, and the pharynx is a conspicuous blood-red. They are found near the low tide-mark, and are very localised in distribution.

Occurrence.—False Bay (37); Table Bay (46); South-West Africa (4).

SPIONIDAE.

NERINE CIR RATULUS (Delle Chiaje) var. CAPENSIS (McIntosh).

Nerine capensis McIntosh, 1924, p. 71.

Occurrence.—False Bay (38).

AONIDES GRACILIS Tauber.

Tauber, 'Annulata danica', 1879, p. 115; Ehlers, 1913, p. 512.

Occurrence.—False Bay (17).

POLYDORA CILIATA (Johnston).

Fauvel, 1927, p. 49, fig. 16 *i-p*.

Occurrence.—Madagascar (19).

POLYDORA ARMATA Langerhans.Fauvel, 1927, p. 55, fig. 19 *a-e*.*Occurrence*.—Cape (38).**POLYDORA (BOCCARDIA) POLYBRANCHIA** Haswell.Fauvel, 1927, p. 58, fig. 20 *a-i*.*Occurrence*.—Luderitzbucht (4).**PRIONOSPIO MALMGRENI** Claparède.Fauvel, 1927, p. 61, fig. 21 *a-e*.*Occurrence*.—False Bay (17); Agulhas Bank (14).**PRIONOSPIO PINNATA** Ehlers.

Ehlers, 1901, p. 163; 1903, p. 111.

Occurrence.—Agulhas Bank and South-West Africa (14); Angola (21).**PRIONOSPIO CAPENSIS** McIntosh.McIntosh, 1885, p. 381, pl. xlv, fig. 7, pl. xxiv *a*, figs. 7, 8.*Occurrence*.—Agulhas Bank (35).**PRIONOSPIO SEXOCULATA** Augener.

Augener, 1918, p. 405, pl. vii, figs. 159-72, text-fig. 52.

Occurrence.—Walvis Bay (4).**MAGELONIDAE.****MAGELONA CINCTA** Ehlers.

Ehlers, 1908, p. 111, pl. xv, figs. 9-12.

Occurrence.—Algoa Bay (14).**CHAETOPTERIDAE.****CHAETOPTERUS VARIOPEDATUS** (Renier).Fauvel, 1927, p. 77, fig. 26 *a-n*.

Collected between the tide-marks at St. James. One specimen. Length 94 mm.

Remarks.—On preservation in alcohol this specimen emitted much dark green pigment.*Occurrence*.—Round South Africa.**THELEPSAVUS VITRARIUS** Ehlers.

Ehlers, 1908, p. 114, pl. xv, figs. 1-8.

Occurrence.—South-West Africa (14).**THELEPSAVUS COSTARUM** Claparède.Fauvel, 1927, p. 82, fig. 28 *a-h*.*Occurrence*.—Madagascar (19).

PHYLLOCHAETOPTERUS SOCIALIS Claparède.

Fauvel, 1927, p. 84, fig. 30 *a-l*, with synonymy.

Occurrence.—Round South Africa.

CIRRATULIDAE.

AUDOUINIA FILIGERA (Delle Chiaje) var. MERIDIONALIS (Marenzeller).

Cirratulus tentaculus var. *meridionalis* Marenzeller; Augener, 1918, p. 461, pl. vi, figs. 175–6.

Collected between the tide-marks at St. James, East London, and Durban. Specimens localized, but fairly common. Length up to 50 mm., breadth 3.2 mm., number of segments 200.

Remarks.—The tentacles arise between the 5th or 6th segment to form an almost complete band across the dorsum. In life this species is dark brown in colour, with slender blood-red branchiae. As in the corresponding European form *A. tentaculata*, most of the specimens are found in black mud in which there is much organic matter.

Occurrence.—Round South Africa.

AUDOUINIA FILIGERA (Delle Chiaje) var. CAPENSIS (Schmarda).

Cirratulus cirratus McIntosh, 1904, p. 67, pl. vi, fig. 30.

Non *Cirratulus cirratus* (O. F. Müller); Monro, 1930, p. 154, with synonymy.

Collected between the tide-marks at St. James, Port Alfred, East London, and Park Rynie (Natal). Specimens common. Length up to 200 mm., breadth 5 mm., number of segments 216.

Remarks.—The South African form differs from the European species (Fauvel, 1927, p. 92) in the manner described by Monro. In life the Cape form is dark brown, the branchiae orange. They have been seen alive in rock pools, where they resemble yellow anemones. The body is buried beneath the sand and coiled, so that the tentacles and branchiae, which wave freely in the water, resemble the tentacles of an anemone. This is undoubtedly a protective imitation.

The Natal specimens differ from the Cape form, having the tentacles and branchiae barred in black; the body also is covered with flecks of black pigment.

Occurrence.—Round South Africa.

CIRRATULUS AFER Ehlers.

Ehlers, 1908, p. 127, pl. xvii, figs. 10–12; Monro, 1930, p. 156, fig. 60.

Occurrence.—South-West Africa (14).

CIRRATULUS CONCINNUS Ehlers.

Ehlers, 1908, p. 128, pl. xvii, figs. 13, 14.

Occurrence.—Agulhas Bank (14).

CIRRATULUS ATROCOLLARIS Grube.

Wiley, 1904, p. 265; Grube, 1887, 'Annel. Gazelle', Monatsber. Akad. Berlin, 1887, p. 536.

Occurrence.—Knysna Lagoon, Cape (47).

HETEROCIRRUS BIOCULATUS (Keferstein).

Fauvel, 1927, p. 96, fig. 33 *i*.

Occurrence.—Angola (4).

HETEROCIRRUS CAPUT-ESOCIS Saint-Joseph var. **CAPENSIS** Monro.

Monro, 1930, p. 156, fig. 61.

Occurrence.—False Bay (41).

CIRROPHORUS BRANCHIATUS Ehlers.

Ehlers, 1908, p. 124, pl. xvii, figs. 5–9.

Occurrence.—Agulhas Bank (14).

DODECACERIA AFRA Augener.

Augener, 1918, p. 468, pl. vii, figs. 254–5, text-fig. 73.

Occurrence.—Luderitzbucht (4).

CHLORAEMIDAE.**FLABELLIGERA AFFINIS** Sars var. **LUCTATOR** (Stimpson).

Flabelligera luctator McIntosh, 1903, p. 53, pl. iv, fig. 25; Monro, 1930, p. 160, fig. 64.

Flabelligera marenzelleri McIntosh, 1903, p. 55, pl. iii, fig. 26.

Collected between the tide-marks at St. James and Port Alfred. Two specimens. Length 30 mm., breadth 5 mm., number of segments 52.

Remarks.—Most authors consider this form identical with the European type. Though it is closely allied, there seems to be a constant difference in the shape of the papillae figured by Monro, and to a less extent in the shape of the hooks figured by McIntosh. I cannot find sufficient difference between the two species described by McIntosh to merit their distinction.

Occurrence.—Round South Africa.

STYLARIOIDES CAPENSIS (McIntosh).

Trophonia capensis McIntosh, 1885, p. 363, pl. xlv, figs. 7–8, pl. xxiii *a*, figs. 1–3;

Monro, 1933, p. 502, synonymy.

Collected in sand near the low tide-mark at St. James and Port Alfred. Specimens fairly common. Length up to 72 mm., breadth 6 mm., number of segments 86.

Diagnosis.—Branchial filaments slender and numerous as in *S. monilifer* (Delle Chiaje). True ventral crotchets commence on 5th segment. Body with regular rows of papillae, not markedly tapered posteriorly. Anterior segments each bear ten papillae, later segments twelve.

Remarks.—This species is covered with a thick cuticle armoured with a coating of sand-grains. The body beneath is dark green, the bristles yellow, the branchiae grass green and the grooved tentacles white. McIntosh remarks that this species is ripe in December; specimens collected in February, April, and September contained no eggs.

Occurrence.—Round South Africa.

STYLARIOIDES XANTHOTRICHUS (Schmarda)

Ehlers, 1908, p. 119, pl. xvi, figs. 1, 2.

Stylarioides swakopianus Augener, 1918, p. 433, pl. vii, fig. 234, text-figs. 61, 62.

Occurrence.—Round South Africa (4, 14, 41).

STYLARIOIDES TROPICUS Augener.

Augener, 1918, p. 437, pl. vii, figs. 220, 221, text-fig. 63.

Occurrence.—Angola (4).

STYLARIOIDES PARMATUS Grube.

Wiley, 1905, p. 289, pl. viii, fig. 5.

Occurrence.—Madagascar (19).

PYCNODERMA CONGOENSE Grube.

Augener, 1918, p. 451, text-fig. 58; Monro, 1930, p. 162, fig. 65.

Occurrence.—Angola (4).

POLYOPHTHALMUS PICTUS Dujardin.

Augener, 1914, p. 37, with synonymy.

Polyophtthalmus australis Grube; Wiley, 1905, p. 289, pl. v, fig. 121.

Occurrence.—Madagascar (19).

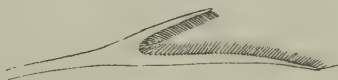


FIG. 12.—*Lipobranchius longisetus* (Schmarda). Bifurcate bristle.

SCALIBREGMIDAE.

LIPOBRANCHIUS LONGISETUS (Schmarda).

Hyboscolex longiseta Schmarda; Augener, 1918, p. 425.

Lipobranchius capensis Wiley, 1904, p. 266, pl. xiii, figs. 23–4, pl. xiv, fig. 14.

Collected between the tide-marks at St. James. One specimen. Length 20 mm., breadth 1.7 mm., number of segments 64.

Diagnosis.—Resembling a small *Arenicola* in form and colour; body inflated anteriorly with 60–64 segments. Prostomium pale with broad transverse lobes. Branchiae absent. Segments rounded, each with four bristle bundles containing small capillaries and forked bristles (text-fig. 12).

Remarks.—The number of segments and the shape of the body immediately distinguishes this species from *L. jeffreysii* (McIntosh).

The type of bifurcate setae figured by Wiley was not seen.

Though Schmarda's genus *Hyboscolex*, founded in 1861, antedates *Lipobranchius* (Cunningham & Ramage, 1888), as Augener points out, yet the former was not defined until 1904, when Ehlers redescribed it for *Oncoscolex*

dichranochaetus, the genera *Oncoscolex* and *Hyboscolex* being synonymous. On account of this confusion the more familiar name is here retained.

Occurrence.—False Bay (*); Table Bay (47); Swakopmund (4).

OPHELIIDAE.

AMMOTRYPANE AULOGASTER Rathke.

Fauvel, 1927, p. 133, fig. 47 *a-e*.

Occurrence.—Off Cape Point; Durban (38).

ARMANDIA INTERMEDIA Fauvel.

Augener, 1918, p. 424.

Occurrence.—Angola (4).

TRAVISIA FORBESII Johnston.

Fauvel, 1927, p. 138, fig. 48 *g-k*.

Occurrence.—False Bay; Agulhas Bank (18).

CAPITELLIDAE.

NOTOMASTUS LATERICEUS Sars.

Fauvel, 1927, p. 143, fig. 49 *a-h*.

Occurrence.—Swakopmund (14); Saldanha Bay and Agulhas Bank (18).

DASYBRANCHUS CADUCUS Grube.

Fauvel, 1927, p. 148, fig. 52 *a-h*.

Collected between the tide-marks at St. James. Specimens common. Length up to 140 mm., breadth 7 mm., number of segments 127.

Remarks.—This is a large form found in association with *Nainereis laevigata* in sandy mud. It is rarely obtained whole.

Occurrence.—False Bay (37); Madagascar (19).

CAPITELLA CAPITATA (Fabricius).

Fauvel, 1927, p. 154, fig. 55 *a-h*.

Occurrence.—South-West Africa (4, 14); Cape (18).

LEIOCHRIDES AFRICANUS Augener.

Augener, 1918, p. 472, pl. vii, figs. 199, 200, text-fig. 74; Monro, 1933, p. 502.

Occurrence.—False Bay (42); Angola (4).

ARENICOLIDAE.

ARENICOLA ASSIMILIS Ehlers var. AFFINIS Ashworth.

Ashworth, 1911, p. 18, figs. 4, 5.

Occurrence.—Table Bay (1); Luderitzbucht (4).

ARENICOLA LOVENI Kinberg.

Ashworth, 1911, p. 1, pl. i, text-figs. 1-3.

Collected at Port Alfred by digging in the sandy mud of the lagoon. Two specimens. Length up to 350 mm., breadth 18 mm., number of segments very large.

Remarks.—A short diagnosis of this species is given by Ashworth, p. 16. It generally resembles a large *Arenicola marina*, differing in the shape of the prostomium, which is cordate with two smaller lobes forming a V. There are 13 pairs of gills, 19 setigers, and numerous tail-segments. The setae approach those of *A. cristata*.

Occurrence.—Saldanha Bay to Durban (I, 34).

MALDANIDAE.

CLYMENE (EUCLYMENE) LUDERITZIANA Augener.

Augener, 1918, p. 481, pl. vi, figs. 144-145, pl. vii, figs. 186, 215, text-fig. 77.

Occurrence.—Luderitzbucht (4).

CLYMENE (EUCLYMENE) LUMBRICOIDES Quatrefages.

Fauvel, 1927, p. 172, fig. 59 a-i.

Collected between the tide-marks at St. James. Four specimens. Length 46 mm., breadth 2.5 mm.

Occurrence.—False Bay (42).

CLYMENE (PRAXILELLA) PRAETERMISSA (Malmgren) var. *CAPENSIS* McIntosh.

McIntosh, 1904, p. 73; Monro, 1933, p. 503.

Collected between the tide-marks at St. James and Port Alfred. Three specimens. Length 82 mm., breadth 3 mm.

Diagnosis.—Generally similar to *Cl. praetermissa*, but having only two short anteanal segments instead of four. Slender type of dorsal bristle pinnate, not smooth.

Remarks.—The tubes are built of large sand-grains and shell-fragments, and are attached to the under sides of stones lying in sandy mud.

Occurrence.—False Bay to Port Alfred (35, 42).

CLYMENE LYROCEPHALA Schmarda.

Schmarda, 1861, p. 15, pl. xix, fig. 164; Augener, 1914, p. 69, and 1918, p. 483.

Occurrence.—False Bay (46); Luderitzbucht (40).

NICOMACHE LUMBRICALIS (Fabricius).

Fauvel, 1927, p. 190, fig. 66 a-i.

Nicomache lumbricalis var. *capensis* McIntosh, 1904, p. 71, pl. vi, fig. 32.

Collected between the tide-marks at St. James. Four specimens. Length up to 130 mm., breadth 4.5 mm.

Remarks.—There are 22 setigers and 2 anteanal segments. The anal funnel is surrounded by 20–26 papillae. The tube is made of large sand grains and shell fragments and attached to the under surface of stones lying in sand.

Occurrence.—False Bay (37) to Saldanha Bay (41).

PETALOPROCTUS MACINTOSHI (Marenzeller).

Augener, 1918, p. 491, with synonymy.

Nicomache macintoshi Marenzeller, 1887, p. 19, pl. i, fig. 8.

Occurrence.—False Bay (37); Luderitzbucht (4).

MALDANE SARSI Malmgren.

Fauvel, 1927, p. 197, fig. 69 *a-i*.

Occurrence.—Algoa Bay (14); Durban (38).

MALDANE DECORATA Grube.

Augener, 1918, p. 475, pl. vii, figs. 191–4, text-fig. 75.

Occurrence.—Angola (4).

GRAVIERELLA MULTIANNULATA Fauvel.

Fauvel, 1919, p. 438, pl. xvii, figs. 58–69.

Occurrence.—Madagascar (19).

OWENIIDAE.

OWENIA FUSIFORMIS Delle Chiaje.

Fauvel, 1927, p. 203, fig. 71 *a-f*.

Occurrence.—Round South Africa.

SABELLARIIDAE.

SABELLARIA SPINULOSA Leuckart var. *ALCOCKI* Gravier.

Fauvel, 1927, p. 208, fig. 73 *k-m*, with synonymy.

Dredged by the s.s. *Pickle* on the Agulhas Bank in 28 fathoms. Length 8 mm., breadth 0·8 mm.

Remarks.—A portion of a colony was obtained, all the individuals of which were very small. The colour in spirit is pale brown, darker anteriorly. The tubes are set close together and are fairly straight. Each is formed of rounded sand grains and lined with a silky secretion. The diameter of the tubes is approximately 1·2 mm., but the mouth is wider.

Occurrence.—Angola (4); Luderitzbucht (23); Agulhas Bank (*).

SABELLARIA SPINULOSA var. *INTOSHI* Fauvel.

Fauvel, 1927, p. 211, fig. 73, with synonymy.

Occurrence.—Madagascar (20); Mosambique (38).

SABELLARIA EUPOMATOIDES Augener.

Augener, 1918, p. 503, pl. vii, fig. 186, text-fig. 83.

Occurrence.—Angola (4).

GUNNAREA CAPENSIS (Schmarda).

Augener, 1918, p. 493; Monro, 1930, p. 176.

Sabellaria capensis McIntosh, 1885, p. 418, pl. xxv a, figs. 24–25, pl. xxvi a, figs. 11–12.

Collected between the tide-marks at St. James and Port Alfred. Specimens numerous. Length up to 63 mm., breadth 8 mm., number of segments 42.

Diagnosis.—Dorsal hooks absent; operculum formed by two rows of large paleae. Three parathoracic segments with large flattened oar-shaped bristles, directed backwards.

Remarks.—Colonies of these worms are common between the tide-marks. A single colony may measure as much as a yard across and is between one and two feet thick. The surface is brown and bare where exposed to the sun, but where shaded it is overgrown with small algae, even the opercula of the worms bearing large growths. Each tube is built of large particles of sand and shell, and is lined with a smooth black secretion. The mouth of the tube is funnel shaped.

Living commensally in the tubes are *Polynoe scolopendrina*, possibly also *Halosydna allenii* and *Harmothoe waahli*, though these latter are less certain, as a number of different forms harbour in the empty tubes. In the interstices of the colony between the tubes are various marine animals:—Hydroids, Polyzoans, Ascidians, Marine Spiders, and Polychaets, such as *Euphrosyne capensis*, *Lepidonotus clava*, Lumbriconereids, Nereids, and Syllids.

The ripe male and female worms are immediately distinguishable by the colour of the body, the male being pale yellow and the female creamy pink. From December to March artificial fertilisation is possible, the eggs being freely extruded on removal of the worm from its tube.

Occurrence.—Round South Africa.

PALLASIA (LYGDAMIS) INDICUS Kinberg.

Johansson, 1927, p. 81, with synonymy.

Tetretes murata (Allen) var. *gilchristi* McIntosh, 1924, p. 76, pl. x, figs. 10–12.

Occurrence.—Off Saldanha Bay (38).

IDANTHRYsus PENNATUS (Peters).

Johansson, 1927, p. 88, with synonymy.

Pallasia pennata Augener, 1914, p. 79.

Occurrence.—Mosambique (43); Madagascar (19).

STERNASPIDAE.**STERNASPIS SCUTATA** (Ranzani) var. **AFRICANA** (Augener).

Monro, 1930, p. 179, with synonymy.

Sternaspis fossor (Stimpson) var. *africana* Augener, 1918, p. 608, text-fig. 109.

Occurrence.—Angola (41).

AMPHICTENIDAE.

PECTINARIA CAPENSIS (Pallas).

McIntosh, 1904, p. 76, pl. vii, figs. 35-6.

Occurrence.—False Bay (37).

AMPHARETIDAE.

AMPHICTEIS GUNNERI (Sars).

Fauvel, 1927, p. 231, fig. 80 a-k.

Occurrence.—False Bay (41).

PTERAMPHARETE LÜDERITZI Augener.

Augener, 1918, p. 505, pl. vii, figs. 222-4, text-fig. 84.

Occurrence.—Luderitzbucht (4).

ISOLDA WHYDAHENSIS Augener.

Augener, 1918, p. 514, pl. vii, fig. 216, text-fig. 87.

Occurrence.—Angola (4).

TEREBELLIDAE.

TEREBELLA LAPIDARIA (Kahler).

Fauvel, 1927, p. 254, fig. 87 f-l.

Occurrence.—South-West Africa.

TEREBELLA PTEROCHAETA Schmarda.

Schmardanella pterochaeta McIntosh, 1885, p. 449, pl. liii, fig. 1, pl. xxvii a, figs. 24-6.

Collected in sandy mud between the tide-marks at St. James and Port Alfred. Specimens common. Length up to 90 mm., breadth of thorax 5 mm., number of segments 136.

Diagnosis.—Two pairs of arborescent branchiae with short terminal twigs; bristled segments 28-33 in number, the shape of the bristles being diagnostic. Hooks with 3-4 teeth above main fang, no lateral teeth.

Remarks.—This species is common round the South African shores, is greenish in colour with red branchiae and a large number of pale tentacles. The tubes are composed of shell and sand grains, and are very fragile.

Occurrence.—Round South Africa.

TEREBELLA SCHMARDAEI, sp. n.

Terebella pterochaeta Schmarda, partim.

Collected near the low tide-mark at St. James. Four specimens. Length up to 55 mm., breadth 4.5 mm., number of segments 68.

Diagnosis.—Three pairs of arborescent branchiae and fourteen ventral pads. Bristles continue to near end of abdomen, anterior bristles with small serrated tips, posteriorly with entire blade serrated. Setigers with two rows of avicular hooks having two teeth above main fang.

Description.—This is a small species with 60-80 segments. The general colour is a pale yellow with bright red branchiae and short white tentacles. There are three pairs of arborescent branchiae, equal in size and with fairly long terminal twigs. The cephalic lobes are without prolongations and there are no lateral lobes on the anterior segments. Fourteen pads are present on the ventral surface, but the last few are not well marked; the first ten are transversely elongated, the last four narrower and longer. Nephridial papillae

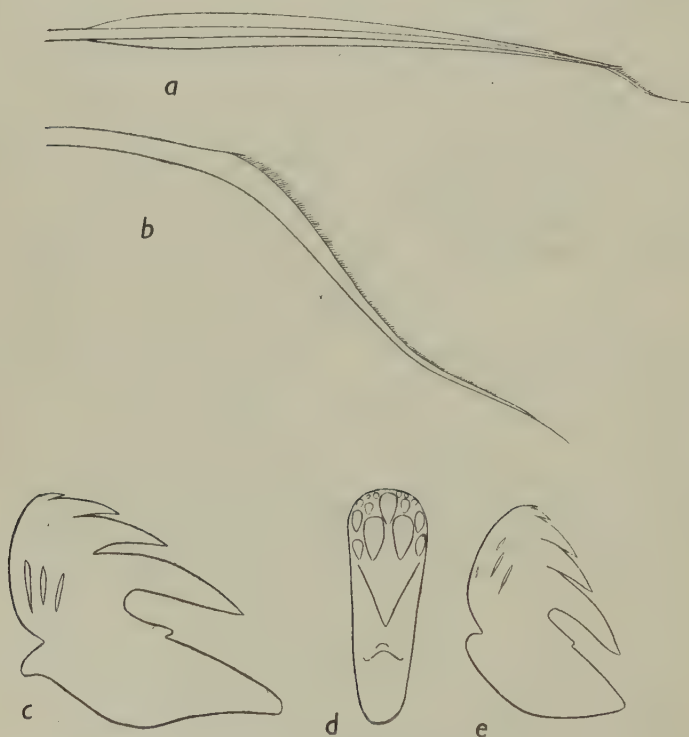


FIG. 13.—*Terebella schmardaai*, sp. n.

a, anterior bristle; b, posterior bristle; c, anterior hook;
d, anterior hook, front view; e, posterior hook.

were not evident on the specimens collected. The thorax is not well marked off from the abdomen. The bristle-bundles, commencing on the 3rd branchiferous segment continue to the 8th or 10th from the anus, which is surrounded by ten papillae. The bristles (text-fig. 13 a) have striate blades with denticulate tips, which become larger posteriorly until the denticulate part constitutes the whole blade (text-fig. 13 b). There is a minute spur at the base of the serrated tips of the anterior bristles, but in the posterior region, where the

serrated portion becomes larger, this disappears. This species is thus in marked contrast with *T. lapidaria*, where the spur becomes larger and larger until it forms one fork of a bifid tip serrated on both its inner edges. The hooks (text-figs. 13 c, 13 e) commence on the second bristled segment, each segment having two rows of hooks placed face to face on well marked ridges. In lateral view there appear to be two teeth above the main fang, but examined face on three to four large teeth can be seen as well as numerous smaller ones (text-fig. 13 d). Posteriorly the ridges become shorter and broader, but never form uncigerous pinnules.

Remarks.—This species was first found by Schmarda in 1861, but the description was confused with that of another species which he took to be the adult form. He thus described *Terebella pterochaeta* as having three pairs of branchiae; McIntosh and later workers have retained this name for the species with two pairs of branchiae. The anterior bristles show a resemblance to those of *T. pterochaeta*, but the serrated portion is smaller and not so sharply curved from the blade of the bristle, and, moreover, they continue to the posterior end of the body. The hooks are somewhat like those of *Terebella grubei* McIntosh, but in other characters the two species are quite distinct.

This species is dedicated to Schmarda, by whom it was first collected.

Occurrence.—False Bay (*).

LANICE CONCHILEGA (Pallas).

Fauvel, 1927, p. 255, fig. 88 a-h.

Occurrence.—Angola (4).

LANICE FAUVELII, sp. n.

Collected by the s.s. *Pickle* on the Agulhas Bank; further locality unknown. Length 70 mm. (incomplete), breadth 5 mm., number of segments 43.

Diagnosis.—Three pairs of densely branched, arborescent branchiae and seventeen bristled segments. The bristles have narrow wings, hooks with 4-5 teeth above main fang; no lateral teeth.

Description.—The specimen is incomplete posteriorly and the tentacles are absent. The general colour in spirit is a slaty brown. The body consists of seventeen bristled segments and twenty-three abdominal segments, though there are probably sixty or more in the complete worm. The thoracic region is of uniform width, but the incomplete abdomen is narrowed posteriorly. The superior lip is horse-shoe shaped and projects so that the mouth opens ventrally. The ventral or posterior lip is small, mucilaginous, and membranous. On the buccal segment there are large mucilaginous ventro-lateral lobes; these form the supports of the ventral lip, but are distinct from it and separate one from the other ventrally. On the third segment there are large membranous lobes, which in this specimen are reflected back to the first bristled segment (text-fig. 14 a). A paired dorsal membrane runs obliquely along the dorsum to end at the 9th bristled bundle on each side.

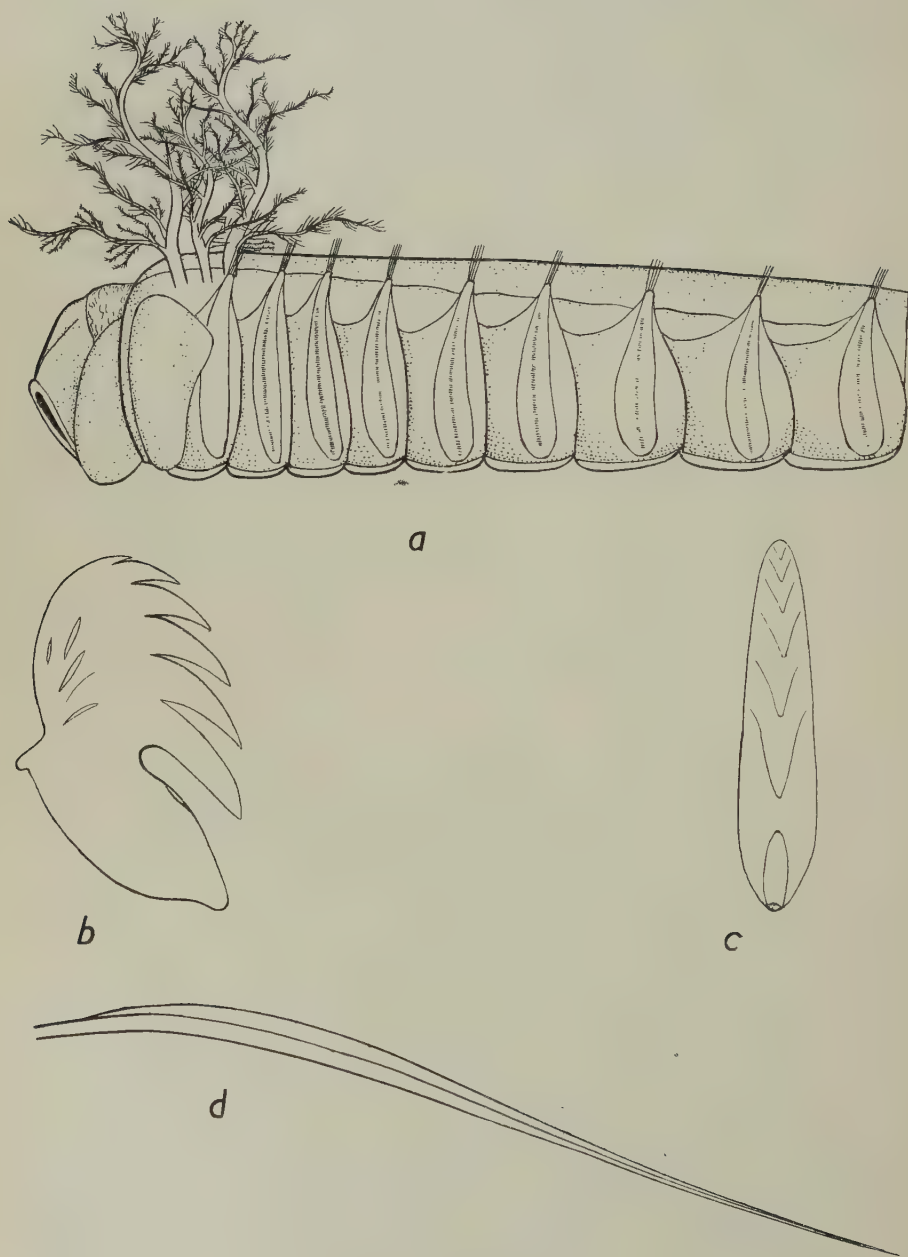


FIG. 14.—*Lanice fauvelii*, sp. n.
 a, head and anterior segments; b, hook in profile;
 c, hook, front view; d, anterior bristle.

There are three pairs of densely branched arborescent branchiae, of which the small terminal twigs are arranged in an open spiral. Of the three, the anterior is the largest. Bristles commence on the third branchiferous segment. The anterior bristles (text-fig. 14 *d*) are finely tapered, with straight narrow blades, those of the posterior segments of the thorax having minutely denticulate tips. These denticulations are so very fine that they can only be seen under oil immersion, and even then they are not always present. The hooks (text-figs. 14 *b* & *c*) are arranged in two rows back to back; there are four large teeth and sometimes a fifth above the main fang. The front view (text-fig. 14 *c*) shows no lateral teeth. The hooks of the abdominal segments, which are exactly similar, are arranged in a single row on long pinnules. There are eighteen to twenty pads, the first eight corresponding with the first eight segments and the last ten distributed between the 9th and the 11th segments.

Remarks.—The hooks of this species differ from those of other members of the same genus, as there are no lateral teeth, but in profile at least they resemble those of *Loimia savignyi* and *Loimia annulifilis* Grube. *Loimia contorta* Ehlers also has no lateral teeth, but this species has only three teeth above the fang. The bristles are similar to those of *Lanice conchilega*, the tips of which are smooth. Since the serrations on the tips of the bristles of *L. fauvelii* are not always visible, their presence cannot be used as a distinguishing character.

I have much pleasure in dedicating this species to Professor Fauvel, to whose works I have so often referred.

Occurrence.—Agulhas Bank (*).

LOIMIA MEDUSA (Savigny).

Loimia annulifilis Willey, 1905, p. 301, pl. iv, figs. 153–4.

Occurrence.—Angola (21); Mosambique (43); Madagascar (19).

POLYMNIA CAPENSIS McIntosh.

McIntosh, 1924, p. 80, pl. ix, figs. 4–6.

Occurrence.—Durban (38).

POLYMNIA NEBULOSA (Montagu).

Fauvel, 1927, p. 257, fig. 89 *a–g*.

Occurrence.—Madagascar (19).

NICOLEA MACROBRANCHIA (Schmarda).

Augener, 1918, p. 527, pl. vii, figs. 232–3, text-fig. 89.

Occurrence.—From Stil Bay to Swakopmund (4, 42, 46).

NICOLEA VENUSTULA (Montagu).

Fauvel, 1927, p. 260, fig. 90 *a–f*.

Occurrence.—False Bay (17).

NICOLEA VENUSTULA var. AFRICANA Augener.

Augener, 1918, p. 524, pl. vii, fig. 242.

Occurrence.—Angola (4).

NICOLEA QUADRILOBATA Augener.

Augener, 1918, p. 532, pl. vi, fig. 183, pl. vii, figs. 226-7, text-fig. 90.

Occurrence.—Swakopmund; Angola (4).

PISTA CRISTATA (O. F. Müller) var. *CAPENSIS* McIntosh.

McIntosh, 1924, p. 82.

Occurrence.—Mosambique (38).

PISTA FOLIIGERA Caullery.

Fauvel, 1919, p. 451, pl. xvii, fig. 80, text-fig. 9, synonymy.

Occurrence.—Algoa Bay (14); Madagascar (19).

THELEPUS CININNATUS (Fabricius).

Fauvel, 1927, p. 271, fig. 95 *i-m.*; McIntosh, 1924, p. 78.

Occurrence.—Mosambique and Durban (38).

THELEPUS PLAGIOSTOMA Schmarda.

Fauvel, 1919, p. 455, text-fig. 10.

Collected between the tide-marks at St. James, Port Alfred, and East London. Specimens common. Length up to 60 mm., breadth 5 mm., number of segments 96.

Diagnosis.—Similar to *Th. setosus*, but dorsal bristles continuing to end of body. Body abruptly narrowed near anus. Prominent pinnules bearing hooks in abdominal region absent.

Remarks.—In the Cape specimens the nephridial papillae have prominent lips, and occur on the 4th to the 7th setigers; all are rarely visible at one time, and in some cases none were distinguished. This character is noted by McIntosh in his description of *Thelepus cincinnatus*. I am doubtful whether his examples refer to the latter species.

Occurrence.—Round South Africa (4, 19, 42).

THELEPUS PEQUENIANUS Augener.

Augener, 1918, p. 545, pl. vii, fig. 259, text-fig. 93.

Occurrence.—Luderitzbucht (4); False Bay (4).

EUTHELEPUS KISEMBOËNSIS Augener.

Augener, 1918, p. 548, pl. vi, fig. 161, pl. vii, fig. 250, text-fig. 93.

Occurrence.—Angola (4).

PSEUDOTHELEPUS NYANGANUS Augener.

Augener, 1918, p. 552, pl. vii, figs. 257-8, text-fig. 96.

Occurrence.—Angola (4).

POLYCIRRUS AURANTIACUS Grube.

Fauvel, 1927, p. 280, fig. 97 *e-k.*

Occurrence.—Angola (21).

POLYCIRRUS SWAKOPIANUS Augener.

Augener, 1918, p. 563, pl. vii, fig. 228, text-fig. 99.

Occurrence.—South-West Africa (4).

TEREBELLIDES STROEMI Sars.

Fauvel, 1927, p. 291, fig. 100 *i-q*.

Occurrence.—Mosambique (38).

COLYMMATOPS GRANULATUS Peters.

Peters, 1854, p. 613.

Occurrence.—Mosambique (43).

SABELLIDAE.

SABELLA MOSSAMBICA Peters.

Peters, 1854, p. 614.

Occurrence.—Mosambique (43).

SABELLA PAVONINA Savigny.

Fauvel, 1927, p. 298, fig. 102 *a-l*.

Occurrence.—False Bay (41).

SABELLASTARTE INDICA (Savigny).

Augener, 1914, p. 115, pl. i, fig. 20, with synonymy.

Eurato sancti-josephi Gravier, 1908, p. 105, pl. vii, figs. 281-3, pl. viii, figs. 284-5, text-figs. 461-62.

? *Dasychone odhneri* Fauvel, 1921, p. 24, pl. i, figs. 10-14.

Occurrence.—Mosambique (38); Madagascar (19).

SABELLASTARTE LONGA (Kinberg).

Monro, 1933, synonymy.

Bispira volutacornis McIntosh, 1904, p. 83, pl. viii, figs. 43-50.

Non *Bispira volutacornis* (Montagu).

Collected between the tide-marks at Umkomaas (Natal), East London, Port Alfred, and St. James. Specimens fairly common. Length up to 150 mm.

Diagnosis.—Resembling *Bispira volutacornis*, but without pick-axe bristles ("soies en pioche"—Fauvel).

Remarks.—In life the bodies of the Cape specimens are brown, and the branchiae are orange-brown. The tubes have a horny substratum for the greater length, but near the free end they are composed of fine sand and mud with a basis of mucus. The Natal specimens were darker in colour and the branchiae were purple, thus showing in colour at least a closer resemblance to *Sabellastarte indica*.

Occurrence.—From False Bay to Durban (37, 41, *).

POTAMILLA RENIFORMIS (O. F. Müller).

Fauvel, 1927, p. 309, fig. 107 *a-l*.

Collected between the tide-marks at St. James. Specimens common. Total length up to 50 mm., breadth 2.3 mm., number of segments 154, length of branchiae 6 mm.

Remarks.—The eyes are in a group placed about the basal third of the branchiae and vary in number from four in juvenile specimens to ten in large individuals.

Occurrence.—False Bay (37); Algoa Bay (38).

POTAMILLA TORELLI Malmgren.

Fauvel, 1927, p. 310, fig. 107 *m-s*.

Occurrence.—Off Saldanha Bay (14, 18).

HYPSICOMUS PHAEOTAENIA (Schmarda).

Fauvel, 1927, p. 312, fig. 108 *a-l*.

Occurrence.—Madagascar (19).

BRANCHIOMMA VESICULOSUM (Montagu).

Fauvel, 1927, p. 315, fig. 109 *a-q*.

Occurrence.—False Bay (17).

BRANCHIOMMA QUADRIOCULATUM Willey.

Willey, 1905, p. 307, pl. vii, figs. 168-9; Monro, 1933, p. 504, figs. 13-20.

Branchiomma mushaensis Gravier, 1908, p. 94, pl. vii, figs. 267-70, text-figs. 447-53.

Collected between the tide-marks at St. James. Specimens common. Total length up to 75 mm., breadth 5 mm., branchiae 10 mm., number of segments 97.

Diagnosis.—Eyes fewer than in *Branchiomma vesiculosum*. Bristles typical of *Potamilla*.

Remarks.—In this collection there is a series from young forms with twelve radioles on each branchial lobe to large forms with twenty-four radioles on each lobe, of which the dorsal sixteen on each side have subterminal eyes. The collar has a very shallow notch laterally. The bristles are similar to those figured by Monro, but the abdominal hooks have broad truncate bases.

Occurrence.—False Bay to Madagascar (42, 20, *).

BRANCHIOMMA BIOCULATUM Ehlers.

Ehlers, 1887, p. 260, pl. liii, figs. 1-9; Augener, 1918, p. 570.

Occurrence.—Angola (4).

DASYCHONE BOMBYX (Dalyell).

Fauvel, 1927, p. 319, fig. 111 *a-l*.

Occurrence.—Off Saldanha Bay (38).

DASYCHONE VIOLACEA (Schmarda).

Johansson, 1927, p. 164, with synonymy.

Dasychone foliosa Ehlers, 1913, p. 572, pl. xlv, figs. 8-16.

Collected between the tide-marks at St. James. Specimens common. Total length up to 50 mm., breadth 6 mm., branchiae 10 mm., number of segments 80.

Diagnosis.—Branchial lobes horse-shoe shaped or forming a single flat spiral; number of radioles 25–36, one-third body length, and with 10–14 external processes and 8–10 eye-spots. External processes large and increasing in size distally. Eyes and external processes absent on last 2–4 ventral radioles. Bristles with short blades; hooks with numerous fine teeth above main fang.

Remarks.—This is a common Cape Sabellid, and it is possible as Monro remarks that *D. natalensis*, here given as a variety of *D. violacea*, is no more than an older form of this species. In the warmer waters of Natal the variety *natalensis* is more common, and it may be that the more luxuriant growth leads to the larger and more complex spiral. In this collection it has always been possible to differentiate the two, so that *D. natalensis* is regarded as a distinct variety of *D. violacea*.

I cannot agree with Johansson that *D. capensis* is synonymous with *D. violacea*, though it is very closely related.

Occurrence.—False Bay to South-West Africa.



FIG. 15.—*Dasychone violacea* var. *capensis* (McIntosh). Hook.

DASYCHONE VIOLACEA var. CAPENSIS (McIntosh).

Dasychone capensis McIntosh, 1885, p. 506, pl. liv, fig. 1, pl. xxxia, figs. 9–11, pl. xxxix a, fig. 8.

Collected at St. James from the sides of aquarium tanks at the laboratory. Length 25 mm., breadth 3 mm., branchiae 10 mm., number of segments 70.

Diagnosis.—Branchiae half length of body. Branchial lobes flat, semi-circular, each bearing twenty radioles. Radioles long and slender with 12–14 external processes decreasing in size distally, branchial tips long, filaments fine. 8–10 eye-spots. Eyes and external processes absent on last 3–4 ventral radioles. Bristles with short broad blades and hooks with fewer and coarser teeth than in *D. violacea typica*.

Remarks.—There is a streak of brown pigment on the short palmar membrane in the intervals between the bases of the radioles. The collar is widely divided dorsally, has a shallow notch laterally, and two lappets just meeting on the mid-ventral line. This variety is distinguished from *D. violacea* by the relative length of the branchiae, the smaller external processes, and the fewer and better marked teeth on the hooks (text-fig. 15).

Occurrence.—False Bay (35, *).

DASYCHONE VIOLACEA var. *NATALENSIS* (Kinberg).

Johansson, 1927, p. 165.

Dasychone violacea McIntosh, 1885, p. 504, pl. liii, fig. 3, pl. xxxi a, figs. 7-8. pl. xxxix a, fig. 7.

Non *Dasychone violacea* Schmarda.

Collected between the tide-marks at St. James and Park Rynie (Natal). Total length 56 mm., breadth 9 mm., branchiae 14 mm., number of segments 88.

Diagnosis.—Branchial lobes in a flat spiral, bearing 46-60 radioles; branchiae one-third length of body, radioles bearing 12-16 external processes, and 8-10 eye-spots absent on last 3-5 ventral radioles. Bristles and hooks as in *Dasychone violacea typica*.

Remarks.—The line of the thoracic bristle bundles curves sharply from those of the abdomen, so that the anterior pair are close together on the dorsal surface. The thoracic rows of hooks decrease in size posteriorly, so that the last is about half the length of the first and is equal to, or shorter than, the first abdominal row.

Occurrence.—Round South Africa (35, 41, *).

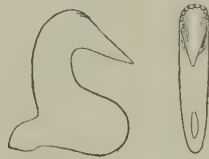


FIG. 16.—*Dasychone nigromaculata* (Baird). Hook.

DASYCHONE NIGROMACULATA Baird.

Johansson, 1927, p. 162, with synonymy.

Dasychone cingulata Grube; Augener, 1914, p. 122, with synonymy.

Dasychone corollifera Ehlers, 1913, p. 571, pl. xlv, figs. 1-8.

Collected between the tide-marks at St. James. Two specimens. Length up to 35 mm., breadth 5.5 mm., length of branchiae 10 mm., number of segments 80.

Diagnosis.—Branchial lobes forming flattened semi-spirals each bearing thirty-six radioles, external processes slender, those at the bases of the radioles longest. Collar dorsally indented and broadly pointed ventrally. Hooks with 1-2 teeth above main fang in lateral view; face on, a semi-circular band of 6-8 teeth can be seen (text-fig. 16). Body brown, with numerous scattered purple spots.

Remarks.—I have examined the hooks of this species with reference to the remarks by Johansson that the difference between *Dasychone* (*Branchiomma*) *nigromaculata* and *Dasychone* (*Branchiomma*) *cingulata* lie in these structures. Viewed laterally, sometimes a single large tooth is visible and sometimes a second small tooth can be seen above the first. The base of the hook is short posteriorly

and in the branchial region appears as figured by McIntosh, 1885, pl. xxxix *a*, fig. 6, but in the abdominal region a form approaching that figured by Ehlers for *D. corollifera* is more common (see Ehlers, 1913, pl. xlv. fig. 7).

The colour in life is olivaceous brown, the branchiae being banded in pink and brown.

Occurrence.—False Bay (17); Madagascar (19).

DASYCHONE ORIENTALIS McIntosh, var.

McIntosh, 1885, p. 498, pl. lii, fig. 5, pl. xxx *a*, figs. 19–21, pl. xxxix *a*, fig. 4; 1924, p. 84.

Occurrence.—Mosambique (38).

MYXICOLA INFUNDIBULUM (Rénier).

Fauvel, 1927, p. 342, text-fig. 119 *a-i*.

Myxicola michaelsoni Augener, 1918, p. 589, pl. vii, figs. 263–4, text-fig. 105.

Collected between the tide-marks in sandy mud at St. James. One specimen. Total length 39 mm., breadth 3.5 mm., length of branchiae 9 mm., number of segments 86.

Remarks.—The colour of the body is pale yellow-green in the living animal, and the branchiae are brown with darker tips. There is a variable number (1–5), but usually 2 minute pigment specks in an irregular row on each segment. The difference between Augener's species and the common *M. infundibulum* lies in the colouring of the branchiae, the size and position of the pigment specks, and to a less degree in the shape of the hooks. These characters are, of course, variable, and my specimen seems to be intermediate between the two species.

Occurrence.—False Bay (*); South-West Africa (4).

SERPULIDAE.

SERPULA VERMICULARIS Linnaeus.

Fauvel, 1927, p. 351, fig. 120 *a-q*.

Occurrence.—False Bay (17); Stil Bay (42).

HYDROIDES UNCINNATA (Philippi) var. *MULTISPINOSA* Marenzeller.

McIntosh, 1924, p. 89, pl. x, fig. 13.

Occurrence.—Table Bay; Durban (38).

HYDROIDES DIPOMA (Schmarda).

Augener, 1918, p. 593, text-fig. 106, with synonymy.

Hydroides uncinnatus var. *macronyx* Ehlers, 1913, p. 582, pl. xlvii figs. 1–2.

Occurrence.—False Bay (17); Angola (4).

HYDROIDES SPINOSA (Pixell).

Pixell, 1913, p. 78, pl. viii, fig. 5.

Occurrence.—Stil Bay (42).

VERMILIOPSIS GLANDIGERUS (Gravier).

Gravier, 1908, p. 121, pl. viii, figs. 290-1, text-figs. 476-81; Monro, 1930, p. 209, fig. 88.

Collected between the tide-marks at St. James. Four specimens. Length up to 21 mm., breadth of thorax 3 mm., length of branchiae 4 mm., number of segments 64.

Remarks.—The tube is white and rounded. The operculum is horny and similar to that figured by Monro, fig. 88 *a*. In life the branchiae are bright red.

Occurrence.—Round South Africa (4, 19, 41).

POMATOLEIOS CROSSLANDI Pixell.

Pixell, 1913, p. 78, pl. ix, fig. 10.

Collected between the tide-marks at St. James, Port Alfred, and Durban.

Diagnosis.—Generally similar to *Pomatoceros triqueter*, but without collar bristles.

Remarks.—In these specimens there were a larger number of radioles than in Pixell's examples. The number varies between 18 and 23. The branchiae are barred in shades of brown beyond the web, which extends half the length of the branchiae.

These worms are found in large colonies of twisted blue and white tubes and are attached to rocks near the high tide mark, the whole colony resembling a Tubularian coral. Two colour varieties were found, one with white and the other with blue or black opercula; this may prove to be a sexual difference.

Occurrence.—False Bay to Durban (42, *).

POMATOCEROS CAERULEUS (Schmarda).

Fauvel, 1919, p. 464, with synonymy.

Pomatoceros strigiceps Ehlers, 1904, p. 67, pl. ix, figs. 11-19.

Occurrence.—Table Bay (46); Madagascar (19).

SALAMANCINA DYSSTERI (Huxley).

Fauvel, 1927, p. 377, fig. 129 *c-k*.

Occurrence.—Angola (4).

PROTULA TUBULARIA Montagu var. CAPENSIS (McIntosh).

McIntosh, 1904, p. 91.

Protula capensis McIntosh, 1885, p. 509, pl. liv, fig. 2, pl. xxxi *a*, figs. 12-13.

Occurrence.—False Bay (35).

SPIRORBIS (DEXIOSPIRA) SPIRILLUM (Linnaeus).

Fauvel, 1927, p. 392, fig. 132 *f-p*.

Occurrence.—Cape (38).

SPIRORBIS (LEODORA) LAEVIS Quatrefages.

Fauvel, 1927, p. 397, fig. 134 *l-p*.

Occurrence.—False Bay (17).

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Reports of an Expedition to Brazil and Paraguay in 1926-7 supported by the Trustees of the Percy Sladen Memorial Fund and the Executive Committee of the Carnegie Trust for Scotland. Copepoda. By A. G. LOWNDES, M.A., F.L.S.

(With 17 Text-figures *)

[Read 12 April 1934]

INTRODUCTION

The species of Copepoda here described were collected by Dr. G. S. Carter at Makthlawaiya and Nanahua in Paraguay. The collection has been of considerable interest and value to me personally, and I am greatly indebted to Dr. Carter for entrusting the collection to my care.

On receiving a collection of this kind it has been my custom to take all the samples and work through them at random, sample by sample. My reason for doing this is that I feel that the less one knows about habitat or proximity of samples the less biassed one will be when considering the final problem.

The following introduction was written immediately after working through the collection and before I had read Dr. Carter's preliminary paper, though I knew, of course, that the waters were characterised by an almost complete lack of oxygen.

My treatment of the species has been greatly influenced by my own prolonged series of breeding experiments, chiefly on *Cyclops*. The value of them may be a matter of doubt, but personally I am convinced that without breeding experiments taxonomy (at least, of Freshwater Entomostraca) must run riot. That taxonomy is getting to an impossible state must be recognised by almost everyone, and I believe that the situation can only be saved by genetics or, at any rate, breeding experiments. Finally, I am convinced that the term *Adaptation to Environment* in its generally accepted meaning is at the present time hardly a scientific conception.

Taxonomy in general.

During recent years a number of expeditions have been made from this country to foreign parts. Usually these expeditions originate from some particular university, and the expeditions thus receive a certain amount of financial support. Usually again the expedition is in charge of some particular leader with some particular object in view. This I take to have been

* The cost of these illustrations has been borne by the Westwood Fund.

the case in the expedition under consideration, in which Dr. Carter went out to the Paraguayan Chaco primarily to investigate *Lepidosiren* and the conditions under which the animals were living—a piece of work which could only have been studied *in situ*.

Of a similar nature, but yet totally different, was the recent Hugh Scott expedition to Abyssinia, where Dr. Scott went primarily to investigate his own particular taxonomic problems, accompanied by Mr. J. Omer-Cooper, who made a study of the fauna and flora of the Abyssinian lakes.

One result of both of these expeditions was that in addition to the investigation of the primary object, a number of collections of various organisms was made and sent to various specialists for identification. While no one would presume to query the value of the primary object of such an expedition, it is, I believe, a very doubtful point whether any real value accrues from these secondary objects *at the present time*, and it is on this part of the programme that I propose to put forward a few remarks.

In the first place, the collecting of the samples requires a considerable amount of care, and takes up a great deal of valuable time on the part of the collector. Frequently the collector knows little or nothing about a large number of the groups that he is collecting. He may frequently make most careful notes about such environmental features as salinity, hydrogen-ion-concentration, temperature, and depth of water. On arriving home the samples are sent to various specialists, who frequently spend an enormous amount of time working them through and describing new species. The value, however, of such papers is considered small unless some statements are forthcoming in which the taxonomist tries to correlate distribution and environmental factors. Nor would it be an exaggeration to state that in many cases the taxonomist is hardly looked upon as a scientist worthy of the name unless he can give, or at any rate attempts to give, some very definite information about the geographical distribution of the species and its causes.

Of course, this does not always apply. Frequently the taxonomist will welcome the opportunity of investigating new material from foreign countries and of enlarging his knowledge of his own particular group; but it is one thing for him to be allowed to pick out certain species, invaluable perhaps to himself in his own investigation, and it is quite another thing if by so doing he is compelled to investigate and describe the whole collection. 'The first, the second and the third duty of the geologist is to travel', wrote Lyell, and the same is almost more true of the taxonomist; but frequently he cannot travel, and foreign collections may therefore be of the greatest value to him.

Now to consider the other side of the matter. A young student going abroad for the first time with collecting material is encouraged to use it, and frequently his 'good conduct marks' depend very largely on the amount of material he has brought back. The fact that he can collect enough material in a few hours to keep a dozen competent taxonomists fully occupied for several weeks may never occur to him, but it is a thing which should be pointed out by his

university. In most cases—but, of course, there are exceptions—a student should collect neither more nor less than he is prepared to try to identify for himself.

The value of working through collections.

No one would deny that in the past most valuable work has been done by working through foreign collections, but whether there is still the same demand for this type of work at the present time is somewhat doubtful, and one may well ask whether our knowledge of species and genera gathered from preserved material does not altogether outweigh our knowledge of the living organism.

Time was when two particular axioms were considered basic to the theory of evolution. They are as follows :—

(1) A change in environment causes a change in the morphology of the individual—or, in other words, produces variation.

(2) Individuals living in different environments constitute different species.

Quite recently the whole matter has received considerable attention from Professor R. A. Fisher in the *Genetical Theory of Natural Selection*, and I for one consider that his primary argument is unanswerable, though its effect on taxonomy is hardly recognised at the present moment.

A failure on the part of many biologists in the past, including Charles Darwin himself, to recognise the *particulate* nature of inheritance and to postulate a *blending* effect, led them to overstress the influence of environment, and to look upon it as the chief cause of morphological variation. A similar error, and one even more prevalent at the present time, may be cited under the term ‘adaptation’, and one is again grateful to the salutary censorship of R. A. Fisher.

The more highly adapted the species, the less possible would it be for an alteration in environment to bring about a beneficial change to the species, and by a beneficial change one means here neither more nor less than one producing a survival value. The taxonomist should hardly concern himself with pathological monstrosities, nor would any thank him for describing them. That the Copepods in general and the Cyclopids in particular represent a set of highly adapted organisms is probably familiar to everyone. Many species of *Cyclops* are world-wide in their distribution, while *Calanus finmarchicus*, a highly adapted Calanoid, extends unchanged over the whole of the Arctic, and perhaps the Antarctic.

I have already stressed the question of the influence of environment elsewhere, and need not repeat what I have written. If one takes a variable wild species such as any of the following, *Cyclops lucidulus* Koch, *C. vulgaris* Koch, *Leptocyclops agilis* Koch, *Mesocyclops obsoletus* Koch, or *Pachycyclops annulatus* Koch, all of which occur abundantly and commonly in the British Isles, and are world-wide in their distribution, one will find that the amount of variation is in no way proportional to the area of distribution. In other words, if one takes a hundred wild specimens from a given pond in the British

Isles, one will find neither more nor less variation by taking a hundred wild specimens of the same species from as many different parts of the earth. Variation is not to be directly correlated with geographical range. For further remarks on this subject see also Gurney (5).

A taxonomist receives a large number of samples of preserved specimens from some particular foreign country, and he proceeds to examine them. He may find a number of well-known European species with which he is perfectly familiar, and he then has something very substantial to go upon, and is able to give in all probability some useful information about distribution and the conditions under which these species occur. It must be remembered, however, that in freshwater entomostraca most of the species are very small and require both careful dissection and measurement before reliable information is gained, and hence the amount of work which can be tackled properly in this direction is limited.

When we come to dealing with unknown species, the work takes on a very different aspect. Consider, for example, some hypothetical specific characteristic and for the sake of simplicity allow that it is transmitted by a single pair of genes. It is obvious that a large proportion of the population will be heterozygous with regard to this factor and may be unrecognisable as such owing to dominance. Few taxonomists would separate a species on a single characteristic, nor is it likely that a single characteristic would be transmitted by a single pair of genes. The greater the number of characteristics considered, the more reliable the specific distinction, but unfortunately the number of specific characteristics apparent is almost directly proportional to the minuteness of the detail studied.

Really the taxonomist is only justified in drawing any conclusions after he has observed a large number of specimens, and even when this is done his knowledge must be lamentably incomplete.

To state specific characteristics with any certainty one requires individuals of three generations (Parents, F. 1 and F. 2 generations). More frequently species are described from a single individual with no knowledge whatever of its parentage or offspring, and remarks about environmental factors and their influence coupled with such incomplete knowledge must be perfectly worthless.

Given a known species and allowing that its individuals are able to breed freely in some such environmental complex as a part of the Paraguayan Chaco, what amount of variation in the individuals might one reasonably expect? If the alteration in environment has any marked effect at all it cannot be a beneficial one, except in the rather rare case in which some particular gene mutation, conferring some advantage, is submitted to natural selection.

It is true that the Paraguayan Chaco, with its very abnormal oxygen content in its surface waters, may be just the type of environment where such selection may occur, but apart from this it is most probable that a large proportion of the individuals, if affected at all, will show pathological modifications.

It can be assumed that gene mutations will be taking place constantly, and the selective influence of the environment on mutant individuals may be effective. What the actual effect will be must be quite unknown at the time of investigation, since one is dealing with an unknown species, apart from the fact that at the present time little or no genetic work has been done on the freshwater entomostraca.

Given certain data the geneticist can supply a great deal of information, but without it he is powerless. It is probable therefore that among such a community as that just described, there will be a number of abnormal individuals, probably destined to perish and of little taxonomic value, while occasionally one may expect to find a new species. To sum up, then, in these foreign collections one may get some useful information about the well-known species, and occasionally one may find a new species, but the description of the latter is quite worthless in a large number of cases, while the majority of individuals in the collections are unsatisfactory for any sort of description, and information gathered about environmental features is practically unusable.

Without over-stressing the taxonomic detail, one may cite two cases which have been brought to light during the study of the present collection. Some thirty years ago, G. O. Sars raised some living specimens from dried mud sent from South America. The specimens showed a peculiar prominence on the last cephalothoracic segment of the female and Sars therefore described and figured the species carefully, naming it *Diaptomus conifer*. Since then a number of species with the same prominence coupled with other slight differences have been described.

The differences have been concerned almost entirely with the structure of the fifth foot both in the male and female and also the structure of the right antennule of the male. Investigation of a number of specimens from a single sample has convinced me that the prominence in question is a very variable characteristic. It may be very conspicuous, or it may be absent, while the same is true of much of the detail of the fifth foot and the antennule of the male. Now if the prominence is due to a single gene a large proportion of the individuals must be heterozygous, as indicated above, and a number of individuals without the prominence are to be expected. The fallacy of separating species on such characteristics is at once apparent, and yet this has been the course adopted by practically all taxonomists in the past.

As a second case I would cite the genus *Mesocyclops*, containing at the present moment some thirty species. Now one of the species, *Mesocyclops obsoletus*, has a singularly useful characteristic in the absence of a spine or seta on one of its swimming feet. The species is world-wide in its distribution and the special peculiarity has been stressed by Sars, Gurney, and myself. The spine in question has, however, seldom been looked for, or its presence or absence noted in any other species of the genus. It is then somewhat unfortunate that so many taxonomists when describing species of this genus make no

mention of the presence of this particular spine. *Mesocyclops obsoletus* is quite abundant in the British Isles and the technique of breeding species of *Cyclops* is quite simple, and it would seem that we have here a really fruitful field for investigation.

As taxonomy progresses, more and more detail is incorporated, with the result that specific distinctions, unless they are carefully tested by breeding experiments become more and more unreliable. Finally, one cannot deny that whenever genetics has been applied to some particular group of organisms it has almost without exception made drastic changes in the taxonomy of the group necessary.

I would suggest, therefore, that some well-organised team work incorporating careful breeding experiments would give far more valuable information than the incessant collection of material from foreign countries, carrying with it its ever-increasing burden of fresh literature.

There is a vast field open in this direction for the student of biometry among the freshwater entomostraca, and no carefully organised expeditions abroad are necessary. One need go no further than Wicken Fen or Wray Castle for the necessary material for carrying out investigations in experimental taxonomy, but such work will require the careful co-operation of the geneticist, the taxonomist, and the experimental biologist.

THE COLLECTION

Altogether thirty-seven samples were worked through and it was found that they contained twenty-one species of Copepods. The species can be classified as follows:—

Calanoids.—Six species of *Diaptomus*, of which three are new to science, while the other three are all confined to South America.

Cyclopids.—Fourteen species, of which five are new to science. Of the remaining nine species, six are confined to the New World, while, of the remaining three, one occurs in Central Africa including Abyssinia, while the two others are well-known European species with a very wide distribution.

Harpacticids.—Only one species of *Canthocamptus* was found, and it was new to science.

The number of Harpacticids was as usual very small, for it is very seldom that these occur in any quantity in a random collection. The collecting of freshwater Harpacticids and also many of the rarer species of *Cyclops* requires a special technique and a considerable knowledge of the group. They are usually to be found in moss-squeezings and hidden away in the rotting stems of water-plants. Finally, the traps of *Utricularia* nearly always provide a good hunting ground.

One of the most remarkable features of the collection is the almost complete absence of so many of the European species of *Cyclops*. One would certainly

expect to find *Cyclops vulgaris*. *Pachycyclops annulicornis*, *Leptocyclops agilis*, and *Mesocyclops obsoletus*. The latter species has been recorded from Paraguay, but I think it is more than likely that the record was really one of the other forms.

The occurrence of *Cryptocyclops varicans* is of considerable interest. It is the type species of the genus and it has a world-wide distribution. In the collection under consideration it frequently occurred in association with *C. anceps*, which is a very common South American species. After this we get it frequently associated with closely allied, but unknown species. Direct evidence is wanting, but the fact remains that it is strongly suggestive of more or less continuous gene-mutation giving rise to new species from a single well-established one.

List of species.

CALANOIDS.

- Diaptomus conifer* Sars.
 „ *coniferoides* Wright.
 „ *deitersi* Poppe.
 „ *carteri*, sp. n.
 „ *echinatus*, sp. n.
 „ *carinifera*, sp. n.

CYCLOPIDS.

- Mesocyclops longisetus* Thiébaud.
 „ *meridianus* Kiefer.
 „ *tenuis* Marsh.
 „ *minutus*, sp. n.
Leptocyclops newmani Pesta.
Platycyclops poppei Sars.
 „ *rubescens* Brady.
Cryptocyclops varicans Sars.
 „ *anceps* Richard.
 „ *mendocinus* Wierzejski.
 „ *elongatus*, sp. n.
 „ *tredecimus*, sp. n.
 „ *brevifurca*, sp. n.
 „ *laticornis*, sp. n.

HARPACTICIDS.

- Canthocamptus richardi*, sp. n.

The nomenclature and classification used is that used by G. O. Sars in Crustacea of Norway, since that of Dr. Robert Gurney was not available when this paper was first written.

The following table gives the references to samples, localities, and species. Dr. Carter's references are as follows :—

PLANKTON SAMPLES. G. S. Carter, S. America, 1926-7.

Localities.

Makthlawaiya. Lat. 23·25 S., long. 58·19 W.

Nanahua. Lat. 23·30 S., long. 59·30 W.

Description of waters.

- A. Swamp at Makthlawaiya. Water at edge of swamp : depth 0-3 ft. only, dry in very hot weather. Covered with floating vegetation of *Pistia*, *Salvinia*, *Azolla*, etc. Bottom black mud.
- B. A similar locality at edge of the swamp at Makthlawaiya, but in water with less floating vegetation.
- E. Rain-water pool in pasture at Makthlawaiya. Only full immediately after rain : bottom mud. Depth 1 ft.
- F. Another rain-water pool in pasture at Makthlawaiya. An artificial hole made by diggings for mud. Bottom grey mud above clay. Depth 3-4 ft.
- G. A rain-water pool in grassland at Makthlawaiya. Only full after rain. Natural depression in level of ground. Bottom turf, 2 ft.
- H. Water over flooded land, shallow, and with a deeper part over dug holes. Depth 1 ft. (flooded land) to 5 ft. (holes). Bottom mud and turf. Makthlawaiya.
- K. A position in the centre of the swamp at Makthlawaiya. Clear water without floating vegetation at the base of tall rushes (*Typha* sp. and other forms). Depth about 3 ft. above mud.

Samples.

Makthlawaiya.

- No. 113. Date, 22.9.26. A.
Copepods were not abundant.
Diaptomus carteri.
Mesocyclops meridianus.
- No. 116. Date, 22.9.26. B.
Diaptomus echinatus.
Cryptocyclops anceps.
Canthocamptus richardi.
- No. 233. Date, 13.10.26. F. Surface.
Diaptomus deitersi.
Mesocyclops meridianus.
- No. 357. Date, 4.12.26. B. After rain.
Diaptomus coniferoides.
Cryptocyclops anceps.
" *elongatus*.
Canthocamptus richardi.

- No. 384. Date, 19.11.26. Lake 5 m. E. of Makthlawaiya, open water, 200×1000 yds.
Depth 2-3 ft., very similar to B. Open water.
Very few copepods present.
Mesocyclops meridianus.
Cryptocyclops anceps.
- No. 386. Date, 25.11.26. Pools at edge of swamp B.
Very few copepods.
Diaptomus carteri.
- No. 387. Date, 27.11.26. F. Bottom.
Diaptomus coniferoides.
Mesocyclops longisetus.
Cryptocyclops anceps.
- No. 389. Date, 29.11.26. F. Top.
Diaptomus coniferoides.
„ *deitersi*.
„ *carteri*.
Mesocyclops meridianus.
„ *tenuis*.
Cryptocyclops anceps.
- No. 390. Date, 29.11.26. F. Bottom.
Diaptomus carteri.
Mesocyclops meridianus.
- No. 391. Date, 30.11.26. H. Surface of deep part.
Diaptomus coniferoides.
Mesocyclops tenuis.
Cryptocyclops anceps.
- No. 716. Date, 27.12.26. G.
Diaptomus conifer.
„ *coniferoides*.
„ *echinatus*.
Mesocyclops meridianus.
Cryptocyclops varicans.
„ *anceps*.
- No. 718. Date, 29.12.26. Pool in pasture 5 miles S. of Makthlawaiya.
Diaptomus coniferoides.
Mesocyclops meridianus.
Cryptocyclops varicans.
„ *anceps*.
- No. 725. Date, 18.12.26. Pools in Rio Verde after some rain. Salinity 1001·8.
Diaptomus coniferoides.
Mesocyclops meridianus.

Nanahua.

- No. 979. Date, 19.1.27. Pools in riacho of Monte Lindo River. Not saline. Edge.
A few immature specimens, but no recognisable copepods.
- No. 981. Date, 30.1.27. Pools in gulley of Rio Verde, 50 m. N. of Nanahua.
Diaptomus coniferoides.
Mesocyclops longisetus.
- No. 982. Date, 30.1.27. Same pools as 981. Middle.
Very few copepods.
Diaptomus coniferoides.

- No. 983. Date, 15.2.27. Dug pool near village.
No calanoids.
Cryptocyclops tredecimus (abundant).
- No. 984. Date, 15.2.27. Pools in Monte Lindo riacho.
Diaptomus echinatus.
- No. 985. Date, 15.2.27. Pool in pasture NW. of Nanahua.
Very few copepods.
- No. 1075. Date, 29.3.27. Dug well 25 miles E. of Nanahua.
Very few copepods. No recognisable adult specimens.
- No. 1076. Date, 30.3.27. Pool in swamp 59 miles NE. of Nanahua.
Diaptomus coniferoides.
Cryptocyclops anceps.
- No. 1077. Date, 31.3.27. Swamp 20 miles W. of Makthlawaiya.
Diaptomus coniferoides.
„ *deitersi*.
Mesocyclops minutus.
- No. 1115. Date, 13.3.27. Pool in pasture near Nanahua.
Diaptomus coniferoides.
Mesocyclops meridianus.
„ *tenuis*.
Cryptocyclops anceps.
„ *tredecimus*.
- No. 1119. Date, 15.3.27. Pool in wood 5 miles NE. of Nanahua.
Diaptomus conifer.
„ *echinatus*.
„ *carinifera*.
Mesocyclops meridianus.
„ *tenuis*.
Cryptocyclops varicans.
„ *anceps*.
„ *tredecimus*.
„ *brevifurca*.
- No. 1126. Date, 17.3.27. Old well 3 miles N. of Nanahua.
Very few copepods.
Cryptocyclops anceps.
- No. 1134. Date, 24.3.27. Another pond at Nanahua.
No copepods.
- Makthlawaiya.
- No. 1146. Date, 12.4.27. Siete Puntas River. Muddy stream flowing through pasture
40 miles SE. of Makthlawaiya.
No recognizable copepods.
- No. 1151. Date, 19.4.27. Rio Verde. 15 miles NW. of Makthlawaiya, in flood.
Immature *Cryptocyclops anceps* (2 specimens).
- No. 1152. Date, 19.4.27. Rain-water pools near bank of Rio Verde.
Diaptomus coniferoides.
Mesocyclops tenuis.
- No. 1153. Date, 19.4.27. Rain-water pools near bank of Rio Verde.
Diaptomus coniferoides.
Mesocyclops meridianus.

- No. 1271. Date, 11.5.27. A. Open water.
Diaptomus confieroides.
Mesocyclops meridianus.
- No. 1283. Date, 18.5.27. Rio Verde stream. Same locality. In flood, not saline.
Diaptomus carinifera.
Mesocyclops meridianus.
Leptocyclops newmani.
Cryptocyclops mendocinus.
- No. 1284. Date, 18.5.27. Rio Verde Stream. Same locality. In flood not saline.
Diaptomus confieroides.
Mesocyclops meridianus.
Cryptocyclops mendocinus.
 „ *anceps*.
- No. 1311. Date, 27.5.27. G.
Diaptomus echinatus.
Mesocyclops meridianus.
Cryptocyclops varicans.
 „ *anceps*.
- No. 1312. Date, 27.5.27. Centre of swamps at Makthlawaiya.
Diaptomus confieroides.
 „ *carteri*.
Mesocyclops longisetus.
Platycyclops rubescens.
 „ *poppei*.
Cryptocyclops anceps.
 „ *laticornis*.
- No. 1313. Date, 27.5.27. H. Flood water flowing over the land eastwards.
Diaptomus confieroides.
 „ *echinatus*.
Mesocyclops meridianus.
Cryptocyclops mendocinus.
 „ *anceps*.
- No. 1316. Date, 14.5.27. H. Flood water flowing over the land eastwards.
Diaptomus carteri.
Mesocyclops meridianus.
Cryptocyclops varicans.
 „ *mendocinus*.
Platycyclops poppei.

DESCRIPTION OF THE SPECIES

DIAPTOMUS CONIFER Sars.

This species has been fully described and figured by Sars and no further description is necessary. Sars obtained his specimens from dried mud from Brazil, and the species appears to be confined to South America. Only a very few specimens were obtained and they were confined to samples Nos. 716 and 1119.

DIAPTOMUS CONIFEROIDES Stillman Wright.

FEMALE.—Length 1.55 mm.

Seen dorsally the animal has a somewhat rectangular appearance. The last thoracic segment is clearly marked off from that preceding it. The penultimate segment may bear a very conspicuous projection or hump, but this may be missing (fig. 1, *a*).

The last thoracic segment is expanded laterally and ends on either side in a well-marked angle bearing a spine. That on the right is slightly less pronounced than that on the left, but otherwise the segment is practically symmetrical. Towards the inner margin the segment bears on either side another small spine, that on the left being the stouter of the two, but both are inconspicuous and only appear under close observation.

The tail consists of three segments. The first or genital segment is longer than the other two combined plus the caudal rami. The genital segment is somewhat expanded in front and is asymmetrical. The right expansion is higher than the left and much more abrupt. Each expansion bears a spine at its widest part. The second segment is very short. The last segment and the caudal rami are symmetrical and bear no special feature.

Seen laterally the animal is boldly arched at both ends of the thorax, while the penultimate segment may bear a very conspicuous hump. Investigation of a large number of specimens from the same sample shows that this hump is of little or no specific value. The lateral expansions are conspicuous. That on the right is rather rounded and the two spines are practically equal in length though rather widely separated. The left side is far more pointed and its two spines appear closer together.

The anterior antennæ do not reach quite to the end of the caudal rami. The 16th joint bears a conspicuous seta reaching well beyond the 21st joint.

Fifth foot.—The first basal segment is quite short and broad and bears dorsally a well-marked spine. The second joint is also short and bears a lateral seta. The first joint of the exopodite is short and stout. The claw of the second joint is stout and bears rather coarse teeth along both its edges. The third joint is well marked off and bears terminally a strong spine and another very fine spine. The endopodite is two-jointed and reaches to a point nearly three-quarters of the way along the first joint of the exopodite. Its structure is shown in the figure (fig. 1, *b* & *c*).

MALE.—Length 1.4 mm.

Seen dorsally there is a well-marked cervical depression separating the first pedigerous segment from the anterior end of the body. The last thoracic segment is well marked off from that preceding it. It is practically symmetrical and bears at each corner a rather long spine. The tail is apparently symmetrical, though in the preserved specimens it is turned to the right. The caudal rami are symmetrical. Seen laterally besides the cervical groove there appears a hyaline bulge where the first pedigerous segment joins on to the anterior part of the body, and there is thus a prominence rather than a depression. The spermatophores appear to be unusually stout.

The left anterior antenna reaches to the tip of the third abdominal segment and bears on the sixteenth joint a rather conspicuous compound seta, though it is nothing like so pronounced as that on the female. The right first antenna bears in its first half no conspicuous spines, but that on the thirteenth is unusually long and stout. On the antepenultimate joint there is a well-marked hyaline membrane, but no extension in the way of a hook etc.

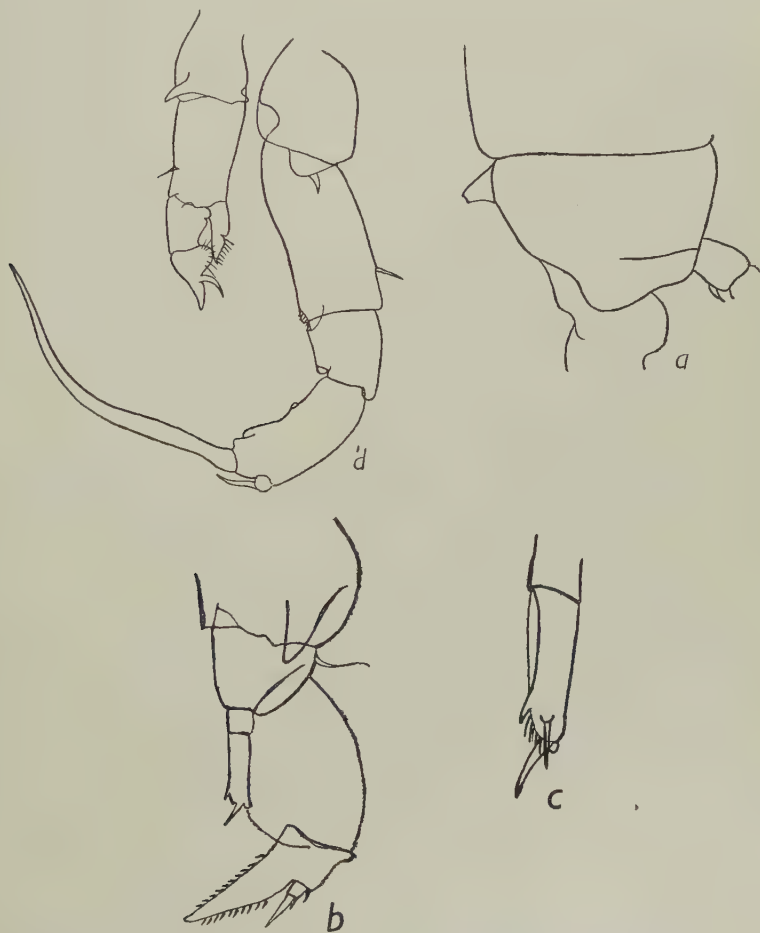


FIG. 1.—*Diaptomus coniferoides* Wright. a. Last thoracic somite of female showing hump. b. Leg 5, female. c. Leg 5, female, endopodite enlarged. d. Leg 5, male.

Fifth swimming foot (right).—The first basal segment is irregular and deeply indented on its inner edge. There is a well-marked spine on the mammiform process at its distal edge. The second basal segment is nearly twice as long as it is broad and three-quarters of the way along its outer edge there is a short seta. The first joint of the exopodite is about as long as it is broad, and both

its distal corners are produced into rounded knobs. The second joint is about twice as long as it is broad. The spine is quite small and of a sigmoid shape. It occurs on a rounded process at the distal corner of the joint and it is quite smooth. On the inner surface of the joint there is a very definite knob. The claw is long and curved and bears fine denticulations along its inner edge. The endopodite is simply a blunt conical process of the second basal segment. The left foot reaches to the end of the second basal segment of the right foot. Its first basal segment bears a strong spine on its outer edge. The second joint is not much longer than it is broad, and bears at a point two-thirds of the way along its outer edge a short seta. The exopodite is two-jointed and is of complicated structure. It ends in a definite claw with a digitiform process on its inner edge. The endopodite consists of a conical process fringed on its inner edge with setæ (fig. 1, *d*).

REMARKS.—I think I am right in referring this species to that partly described and figured by Stillman Wright, though it differs in several details. It is a very variable species, particularly in the nature of the hump on the penultimate segment of the thorax in the female. It is by far the most abundant species in the collection and it occurred in eighteen samples out of the thirty-seven investigated.

DIAPTOMUS DEITERSI Poppe.

FEMALE.—Length 1.6 mm.

Seen dorsally the body is decidedly elongated. The cervical groove is well-marked and the last thoracic segment is not confluent with that preceding it. The last thoracic segment is not expanded laterally at its distal corners and it is practically symmetrical, though the right corner is rather less rounded than the left. On each side there is a small spine. Seen laterally the posterior edge of the penultimate segment of the body bears a definite pyramidal projection, but this projection is covered with minute spinules and thus differs from *D. conifer* Sars or *D. coniferoides* Stillman Wright. The abdomen consists of three segments, of which the first is twice as long as the other two (exclusive of the actual caudal rami). It is only slightly expanded at its base and is practically symmetrical. On either side there is a spine, but that on the right side is higher than that on the left. The antennæ reach to the tip of the setæ of the caudal rami. The caudal rami are perfectly symmetrical.

The fifth foot.—The structure of the fifth foot is shown in the figure (fig. 2, *a*). The third joint of the exopodite is fairly distinct and bears a short spine and a longer seta. The endopodite is distinctly two-jointed, the two joints being of unequal length. The second joint bears terminally two short spines and a row of setæ. The length of the exopodite varies somewhat, but it is approximately half the length of the first joint of the exopodite.

MALE.—Length 1.46 mm.

Seen dorsally the body is not greatly elongated. The last thoracic segment is not expanded laterally and is practically symmetrical. There is a small

spine at each corner, but that on the right is longer and stiffer than that on the left, and this at times gives a slightly asymmetrical appearance.

The tail consists of five joints, of which the first bears a minute spine at the distal corner on the right side. The joints of the tail appear to be perfectly symmetrical, though the tail itself is usually turned to the right. Seen laterally there is not the slightest sign of any pyramidal process on the penultimate thoracic segment, nor is there any sign of spinules. The antennae are long, and reach back to the end of the caudal rami. The right antenna is modified in the usual way. The antepenultimate joint bears a hyaline membrane that is only seen with difficulty. The spine, which always appears on the 8th segment of this antenna, is in this species unusually prolonged and is as long as the spines found on the 10th and 11th segments. The spine on the 13th segment is not, however, very pronounced relatively.

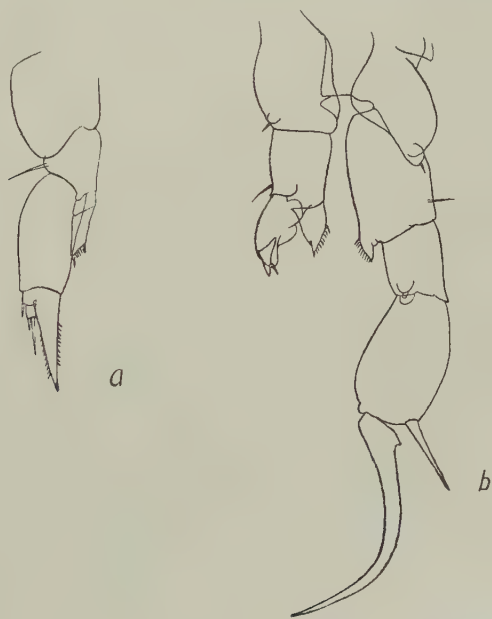


FIG. 2.—*Diaptomus deitersi* Poppe. a. Leg 5, female. b. Leg 5, male.

The fifth foot (right) (fig. 2, b).—The basal joint is broad and bears at its outer corner a mammiform process with a spine, while its inner corner is deeply indented. The second basal joint is almost as broad as it is long, and the structure of its inner edge is difficult to make out. In some specimens it has simply the appearance of a hyaline membrane bearing a conical process without any appearance of a joint at its base. Or there may appear no hyaline membrane, and the conical process at the top may appear at the base, in which case it is of course the endopodite. In either case it bears two or three small

spines and a row of setæ. There is a seta on the outer edge of the second basal joint. The first joint of the exopodite is rather elongated with each distal corner produced as a rounded knob. It bears no seta on its outer edge. The terminal joint is rather enlarged distally, giving it a broad oval appearance. The spine occurs nearly $\frac{3}{4}$ of the way along its outer edge. This spine is rather elongated and quite smooth; in some cases it is subdivided. The claw is stout and enlarged at its base. The spine may or may not bear some very fine denticles.

The left foot.—The basal joint is rather longer than the corresponding joint of the right foot. $\frac{3}{4}$ of the way along its outer edge it bears a process with a spine. The second basal joint is shorter than the corresponding joint of the right foot. It bears a seta $\frac{3}{4}$ of the way along its outer edge. The endopodite consists of a conical process which shows a fairly definite suture at its base, while distally it ends in an oblique row of setæ with a small spine at each end. The exopodite is a complicated structure indistinctly divided into two. The end joint is terminated by a claw-like process, which bears on its inner edge a bent finger-like process. Both joints bear on their inner edges rounded processes bearing setæ.

REMARKS.—The species has been partly described and figured by Poppe and Mrázek and also by Stillman Wright. It occurred in three out of the thirty-seven samples. The specimens show a considerable amount of variation in minute detail, but there is no justification in trying to correlate this with habitat.

DIAPTOMUS CARTERI, sp. n.

FEMALE.—Length 1.46 mm.

Seen dorsally the animal appears to be somewhat elongated. There is a well-marked cervical groove, and the last thoracic segment is not confluent with that preceding it. The hinder edge of the last thoracic segment is expanded, forming a well-marked process on either side. The two corners are nearly symmetrical, though the left one is slightly longer than the right. At either corner there is a well-marked spine. The tail consists of three joints, of which the first is considerably expanded at its base, forming on either side a rounded protuberance. The segment is not symmetrical, since the bulge on the left side is more abrupt than that on the right. Each bulge bears a spine, though that on the right side is slightly higher up than that on the left. The second segment is short, though longer than in *Diaptomus deitersi*. The caudal rami are slightly asymmetrical, the left being slightly longer and broader at the base. Seen laterally the first thoracic segment appears boldly arched. The penultimate thoracic segment bears a conspicuous pyramidal process like that of *Diaptomus conifer* Sars. It is devoid of spinulae. The tail is short, with the seminal receptacle on the first segment pronounced. The genital segment is also boldly extended dorsally at its posterior edge. The antennae reach practically to the end of the setae of the caudal rami.

Fifth foot.—The structure of the fifth foot is shown in the figure (fig. 3, *a*). The endopodite consists of two joints, though the division is not always clearly marked. The end joint of the endopodite bears three spines and a row of setae (fig. 3, *b*).



FIG. 3.—*Diaptomus carteri*, sp. n. *a*. Leg 5, female. *b*. Leg 5, female, endopodite enlarged. *c*. Last thoracic and first tail somite, male. *d*. Leg 5, male.

MALE.—Length 1.35 mm.

Seen laterally there is a well-marked cervical groove. The first pedigerous segment is clearly marked off from the preceding one. The last thoracic segment is not confluent with the segment preceding it. Seen dorsally the last thoracic segment is symmetrical. The first tail segment is somewhat

telescoped in the preserved specimens and is, therefore, difficult to make out. At its distal corner on the right side there is a minute spine as in *Diaptomus dietersi* (fig. 3, c). The remaining segments and the caudal rami are symmetrical.

Right antenna.—The first part is somewhat thickened, while the middle part is decidedly so. Hooked spines occur on the 10th and 11th joints, while that on the 13th is stout and fairly long, reaching to the end of the next joint. On the 15th segment, in addition to the ordinary spinous process, the anterior seta has become decidedly spiniform. The antepenultimate segment bears a well-marked hyaline membrane.

Fifth foot (right) (fig. 3, d).—The first basal segment is irregular. It is deeply indented at its inner corner with a very pronounced mammiform process, bearing a small spine, near its outer corner. The second basal segment is rather broad. It bears a seta about two-thirds of the way along its outer edge. The distal half of the joint bears towards its inner edge a pronounced ridge. The first joint of the exopodite is slightly longer than it is broad, with its inner and outer distal corners produced into rounded processes. The second joint is somewhat oval in shape and bears terminally a spine that is somewhat stout and distinctly bent outwards. The claw is stout and rather short, and somewhat swollen at its base. It is quite smooth except for a short row of minute teeth near the middle of the inner edge. The endopodite consists of a well-marked hyaline conical process. It bears a row of hairs along its inner edge.

Left foot.—The first basal joint bears a mammiform process and a spine at its outer distal corner. The second basal joint is rather broad. The exopodite is two-jointed, each joint bearing a ciliated pad on its inner edge. The second joint ends in a definite claw-like process, and bears a finger-like process on its inner edge. The endopodite is rather pronounced and somewhat sharply pointed.

REMARKS.—This seems to be a perfectly distinct species. In the female it is distinguishable by the shape of the genital segment, while in the male the spines on the right antenna and the structure of the right fifth foot make it fairly easy to recognise. The species is fairly abundant and occurred in six out of the thirty-seven samples. As in so many of these South American species there is a considerable amount of variation in detail. In some specimens the large claw on the second joint of the exopodite of the right fifth foot is distinctly divided.

DIAPTOMUS ECHINATUS, sp. n.

FEMALE.—Length 1.6 mm.

The body is not elongated. There is a well-marked cervical groove, and the rostrum bears two typical seta-like appendages. The last thoracic segment is not confluent with that preceding it. It is slightly asymmetrical, the left side being slightly more expanded and reaching a little further towards the

tail. On either side there is a well-marked spine. The tail consists of three segments, of which the genital segment is rather longer than the other two together. This segment is strongly dilated near the base, so that its greatest width is practically equal to its length. It is somewhat asymmetrical, the left side being more expanded than the right. At the widest part on each side there is a spine. The second segment is quite short. The caudal rami are quite symmetrical.

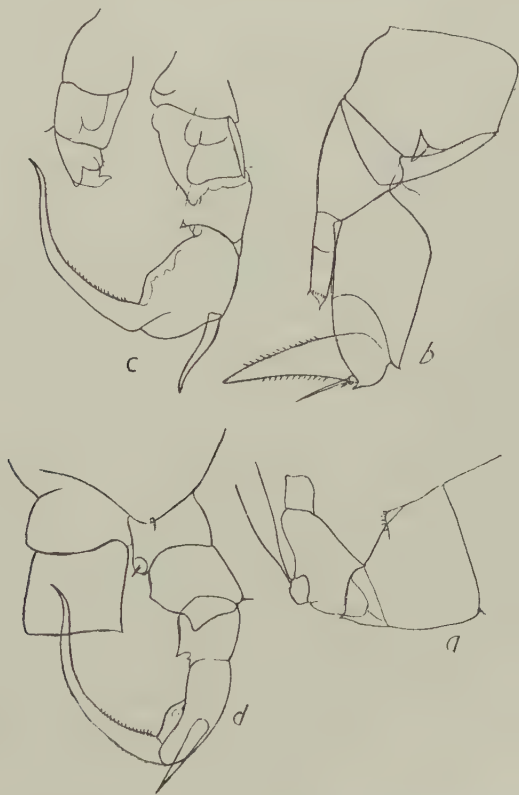


FIG. 4.—*Diaptomus echinatus*, sp. n. a. Last thoracic somite and genital somite, female. b. Leg 5, female. c. Leg 5, male. d. Leg 5, male (different view).

Seen laterally the last segment (fig. 4, a) has a strong suspicion of bearing a hump, as typified in *Diaptomus conifer* Sars, though it is far less marked. The region surrounding the hump is covered with minute spinules. The genital segment bears at the genital opening a tongue-shaped process. The second segment considerably overlaps the last segment dorsally. The antennae reach beyond the setae of the caudal rami.

The fifth swimming feet (fig. 4, b) are rather stout. The first basal joint bears a strong spine on its outer distal corner. The first segment of the

exopodite is about one and a half times as long as it is broad. The claw of the second joint is rather long and bears fine teeth along both its edges. The third joint is clearly marked off, and bears one long seta which reaches as far as the mid-point of the claw of the second joint, while there is also a much shorter spine. The endopodite is two-jointed. The whole joint reaches to about the mid-point of the first joint of the exopodite. The two joints are practically equal in length. The tip of the second joint bears two fine spines and a row of hairs.

MALE.—Length 1.5 mm.

Seen laterally there is a well-marked cervical sinus, while the last thoracic segment is not confluent with that preceding it. Seen dorsally the last thoracic segment is perfectly symmetrical; each corner is provided with a fine spine. The first tail segment is perfectly symmetrical and bears no spines.

The right antenna bears hooked spines on the 8th, 10th, 11th, and 13th joints. The spine on the 13th joint is particularly stout. The antepenultimate joint has its distal corner extended to form a hooked process, which points directly out from the antenna. This process may be replaced by a seta.

The fifth foot (right) (fig. 4, c & d).—The first basal segment bears on its inner distal corner a well-marked mammiform process bearing a spine. Dorsally the first basal joint considerably overlaps the second. The second joint bears on its outer edge a fine seta. The first joint of the exopodite is about as broad as it is long, both its distal corners carrying stout hyaline pointed processes. The second joint is broad and somewhat tumified distally. The lateral spine is very broad at the base. Its inner edge is finely toothed. The spine is not as long as the joint. The claw is also stout at its base and rather short. It is finely toothed along the whole of its inner edge. The endopodite is difficult to see, and it appears to be simply a process of the second basal joint. It consists of a simple unjointed conical process bearing a ring of fine spines around its point. The left foot reaches only just beyond the base of the exopodite of the right foot. Both basal joints are broad. There is a fine spine on the outer distal corner of the second joint. The last joint is very irregular, consisting of several lobed processes. It ends in a digitiform extension, while nothing referable to an endopodite can be made out.

REMARKS.—The species was fairly abundant, occurring in six out of the thirty-seven examples.

DIAPTOMUS CARINIFERA, sp. n.

FEMALE.—Length 1.52 mm.

Seen dorsally the body is not particularly elongated. There is a well-marked cervical depression, while the last thoracic segment is confluent with that preceding it. The rostrum does not bear two seta-like appendages, but these are replaced by two small plate-like processes (fig. 5, a). The last thoracic segment is expanded slightly at its distal corners and the expansions are asymmetrical. The outer corner of each expansion ends in a spine, but that on the right points directly outwards, while that on the left points more towards

the posterior end. The spine on the left corner is both stouter and occurs further down (more posterior) than that on the right. On the inner corner of each expansion there is a minute spine (fig. 5, *b*).

The tail consists of three segments, of which the first (the genital segment) is rather longer than the other two together. The genital segment is very little expanded at its base, but it is considerably overlapped by the last thoracic

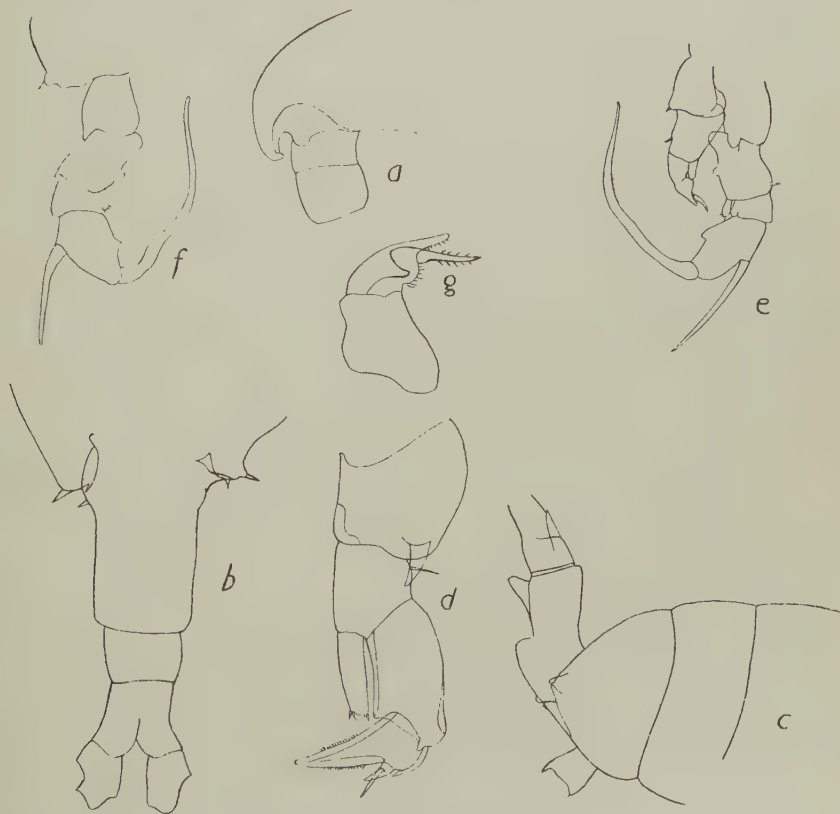


FIG. 5.—*Diaptomus carinifera*, sp. n. *a*. Rostrum, female. *b*. Tail somites, female. *c*. Last two thoracic somites and genital somite, female (showing keel). *d*. Leg 5, female. *e*. Leg 5, male. *f*. Leg 5, male (another view). *g*. Leg 5, male last two joints of left exopodite.

segment. It is slightly asymmetrical and bears a spine on either side. That on the right is stouter and higher up than that on the left. The second segment is nearly as long as it is broad, while the last segment and caudal rami are asymmetrical.

Seen laterally the animal has a perfectly characteristic appearance, on account of the genital segment, which bears a keel-like process in the median line of its posterior edge (fig. 5, *c*). The antennae reach to the tips of the caudal rami.

Fifth swimming foot (fig. 5, *d*).—The first basal joint is short and stout, and bears at its outer distal corner a strong spine. The second joint is short and bears a fine seta at its outer edge. The first joint of the exopodite is about one and a half times as long as it is broad, and both its inner and outer edges are slightly curved. The claws of the second joint is short and stout with its edges strongly thickened, and bearing minute teeth along both its edges. The outer corner of the joint is thickened and expanded into a minute spine. The third joint is quite clearly marked off. It bears one short and thick spine, and another much longer and thinner spine. The endopodite is single-jointed and is as long as the first joint of the exopodite.

MALE.—Length 1.28 mm.

Seen laterally there is a well-marked cervical depression. The last thoracic segment is not confluent with the one preceding it, and ends somewhat abruptly. Seen dorsally the last thoracic segment is symmetrical, each corner bearing a minute spine. The tail is five-jointed, and the first segment bears at its right distal corner a minute spine. The caudal rami are symmetrical.

The right antenna bears well-marked spines on the 8th, 10th, and 11th joints, while that on the 13th joint is particularly strong. The antepenultimate joint bears a hooked process, which is smooth. It extends practically to the distal end of the last joint.

The fifth foot (right) (fig. 5, *e* & *f*).—The first basal joint bears no indentation on its inner edge, but distally and dorsally that edge bears a mammiform process with a spine. The second joint is rather short and irregular. Two-thirds of the way along its outer edge it bears a seta, while its inner proximal corner is produced into a rounded hyaline knob. Halfway along the same edge there occurs a very well-marked rounded knob. The first segment of the exopodite is very short. Its outer edge is produced distally into a rounded process, but it bears no seta or spine. The second joint is small and angular. The lateral spine is quite twice the length of the joint and its origin is about one-third of the way along the joint. It at once curves inwards and is quite smooth. The inner edge of the joint bears an angular process at its mid-point. The end claw is very long and is bent. It is rather expanded at its base and bears some minute teeth close to its base. The extreme tip is bent outwards slightly. The endopodite consists of a single joint. It is as long as the first joint of the exopodite and consists of a rounded process bearing a row of setae at its distal edge.

The left foot is much shorter than the right. The first basal joint is fairly regular, but bears at its outer distal corner a mammiform process with a spine. The second tapers distally. It is about as long as it is broad and bears a minute seta just beyond the mid-point of its outer edge. The exopodite is two-jointed (fig. 5, *g*). The distal joint consists of a rounded process bearing three protuberances. The inner one is just a small blunt extension, the median is a finger-like process longer than the joint itself, while its inner and outer edges are minutely toothed. The outermost of the three protuberances is a short

finger-like process toothed along its inner edge. The endopodite is single-jointed, and is just a rounded process which reaches as far as the first joint of the exopodite.

MESOCYCLOPS LONGISETUS Thiébaud.

The following dimensions (in millimetres) were obtained from a typical adult female :—

Length (exclusive of setae)	1.66
Length of trunk	1.08
„ tail .....	.58
„ cephalic segment .....	.60
„ last three tail segments .....	.22
„ genital segment .....	.22
„ caudal rami .....	.12
„ inner apical seta .....	.76
„ outer apical seta .....	.53
„ inner corner seta .....	.40
„ outer corner seta .....	.11
„ dorsal seta .....	.11
Width of cephalic segment .....	.58
Greatest width of genital segment .....	.20
Least width of caudal rami .....	.044
Fourth swimming foot, inner ramus, terminal joint:	
Length of joint .....	.100
Greatest width of joint .....	.044
Inner terminal seta .....	.072
Outer terminal seta .....	.082

FEMALE.—The body is distinctly robust, with the anterior division tumid. The line of greatest width lies practically across the mid-point of the cephalic segment. The cephalic segment is not particularly elongated, being only one-fifth longer than the succeeding four segments combined. The last trunk segment is small, being very little wider than the genital segment. The tail is not slender, being little more than half the anterior division. The genital segment (fig. 6, *a*) is not elongated nor is it particularly dilated in front. Its length is equal to that of the three succeeding segments.

The caudal rami are not elongated, being rather less than three times as long as broad. They are rather shorter than the last two tail segments. Along their inner edges there are hairs. The lateral seta occurs at a point two-thirds of the distance along the rami. The apical setae are long and slender, the inner seta being longer than the tail. The outer corner seta, the dorsal seta, and the caudal rami being all about the same length, while the inner corner seta is over three times as long. The anterior antennae (fig. 6, *b*) are seventeen-jointed. They are very well supplied with setae and are rather short, not reaching when reflexed beyond the middle of the second segment. The sixteenth joint is rather longer than the seventeenth. Both segments bear a hyaline rib, which in the last segment is finely toothed and bears two semilunar incisions, though in this species, as in nearly all species of the genus,

this hyaline membrane is very variable (fig. 6, *b*). The posterior antenna is decidedly elongated as in *M. obsoletus* Moch. The third joint bears nine setae (fig. 6, *c*).

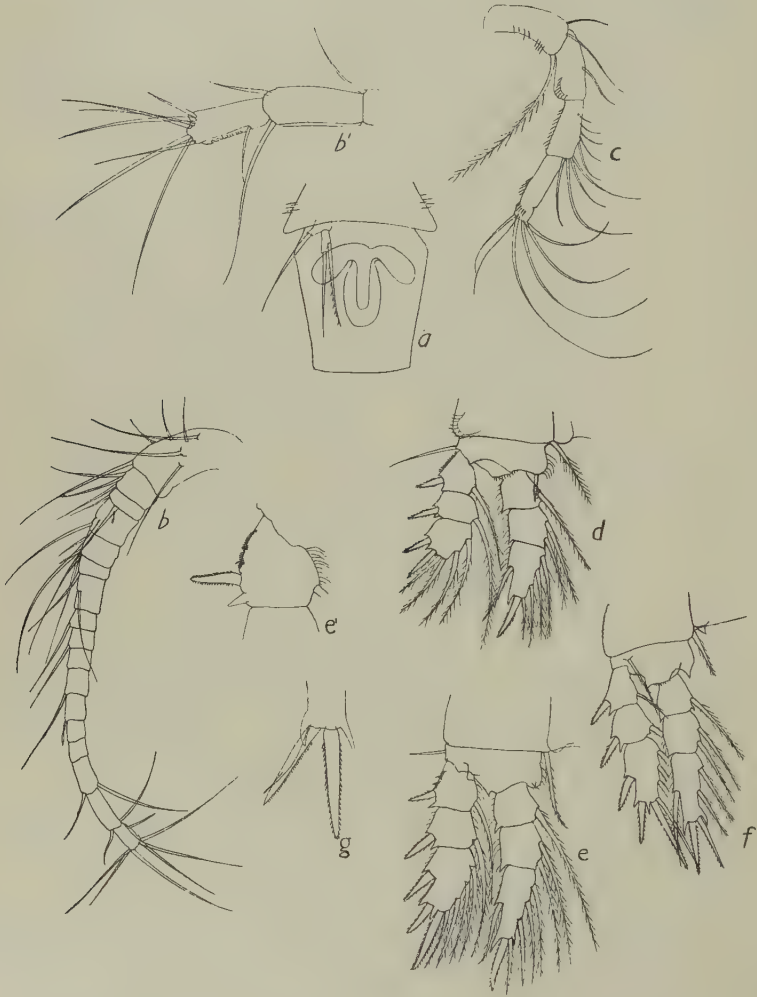


FIG. 6.—*Mesocyclops longisetus* Thiébaud. *a*. Genital segment and fifth foot, female. *b*. Anterior antenna, female. *b'*. Anterior antenna, female, joints 16 and 17, enlarged. *c*. Posterior antenna, female. *d*. Leg 1, female. *e*. Leg 2, female. *e'*. First joint, exopodite, leg 2, female. *f*. Leg 4, female. *g*. Leg 4, female, spines on terminal joint, inner ramus.

The anterior maxillipeds are identical with those of *M. obsoletus*, having the posterior edge of the basal part distinctly crenulated. The posterior maxillipeds are again typical.

The swimming feet are different from those of *M. obsoletus*, none of them being in any way elongated. In the first swimming foot there is a very definite seta on the inner corner of the second basal joint. In *M. obsoletus* the outer edges of the outer rami of the first three pairs of swimming feet bear very fine teeth, but in the species under description these teeth are restricted as follows. On the first foot they are confined to the first joint only. In the second and third feet they are confined to the first joint and the distal half of the third joint. These teeth on the first joint have a peculiar structure not occurring on the actual outer edge. This is shown in the diagram (fig. 6, e).

In the fourth foot the terminal joint of the outer ramus, and also of the inner ramus, is comparatively robust. The spines of the terminal joint of the inner ramus are practically equal in length, but the inner spine is peculiar in possessing a keel that ends in a sharp stylette, which is, I believe, unknown in any other species of *Cyclops* (fig. 6, g). The connecting plate of the two rami of the fourth pair of feet is practically identical with that of *M. obsoletus* (fig. 6, e). The last pair of legs have their basal joint rather broad, as shown in the figure (fig. 6, a). The seminal receptacle is conspicuous with the lateral lobes very well marked (fig. 6, a). On dissecting out the last swimming foot it will be noticed that the last trunk segment bears a few rather inconspicuous hairs. These are not seen in the whole specimen. In the preserved specimens the colour is distinctly dark.

REMARKS.—During my preliminary examination I came to the conclusion that this was a new species, and the peculiar nature of the spines on the terminal joint of the fourth swimming feet might still justify this conclusion. Not more than six specimens were obtained from the three samples in which it occurred, and one did not show that peculiarity. I conclude, therefore, that the species should be referred to *M. longisetus* of Thiébaud.

MESOCYCLOPS MERIDIANUS Kiefer.

FEMALE.—Length without setae 1.24–1.5 mm.

Measurements taken in millimetres from two adult females :—

Length (exclusive of setae)	1.34	1.44
Length of trunk .....	.84	.9
„ tail .....	.5	.54
„ cephalic segment .....	.44	.48
„ genital segment .....	.17	.20
„ last three tail segments .....	.22	.22
„ caudal rami .....	.11	.13
„ inner apical seta .....	.48	.53
„ outer apical seta .....	.36	.38
„ inner corner seta .....	.22	.28
„ outer corner seta .....	.07	.09
Width of cephalic segment .....	.42	.48
„ 4th trunk segment		
Greatest width of genital segment .....	.14	.16
Least width of caudal rami .....	.028	.03

Measurements in millimetres, P. 4, R 1, 3rd joint :—

	1.	P. 4. 2.	3.
Length	·076	·084	·08
Width	·03	·034	·034
Inner terminal spine	·066	·076	·06
Outer terminal spine	·08	·078	·06

DESCRIPTION.—The body is moderately slender, with the anterior part regularly oval in outline. The line of greatest width lies rather behind the mid-point of the cephalic segment, and its length slightly exceeds half the length of the trunk. The length of the cephalic segment is about equal to its greatest breadth, and is also about equal to that of the next four segments combined. The last trunk segment is slightly wider than the genital segment in its widest part. It bears laterally a number of stiff hairs, but these may be replaced by spinules. The tail is fairly slender, being not quite two-thirds the length of the anterior region. The shape of the genital segment varies considerably, but it is usually rather longer than broad, though its length is less than that of the next three segments combined. In some specimens it appears to be quite short and the integument may bear a series of ring-like markings. It may be somewhat inflated at its widest part. The anal segment is about the same length as the preceding segment, but it may be slightly shorter (figs. 7 *a* & 8 *a*).

The caudal rami are of medium length, being about four times as long as broad. They are slightly divergent, while their inner edges may or may not be hairy. The lateral setae are rather pronounced and stand out stiffly. Their position is two-thirds the distance along the rami. The apical setae are comparatively short and spreading. The inner corner seta is quite twice the length of the rami and three times the length of the outer corner seta. The dorsal setae are very fine and are shorter than the outer corner setae (fig. 7, *b*, *b'*, & *b''*).

The anterior antennae (fig. 7, *b*, *b'*, & *b''*) are rather long and reach back as far as the distal edge of the second trunk segment. They are 17-jointed, and of these joints the last two are rather elongated and bear a definite hyaline membrane. This membrane is either smooth or very finely serrated in the 16th joint, while in the 17th there may be one or several coarse teeth or notches. Breeding experiments on the type-species have shown me that little or no specific importance can be attached to the structure of this membrane. There are some very conspicuous setae on the antennae, especially those attached to the 3rd and 4th joints. The 17th joint is slightly longer than the 16th. The *posterior antennae* are elongated (figs. 7 *c* & 8 *b*). The third segment bears from 7 to 9 setae and is shorter and stouter than the fourth segment. The terminal seta of the fourth segment is thickened and may bear very definite teeth along its inner edge.

The *anterior maxillipeds* (fig. 7, *d*) are identical with those of the type-species, except that the crenulate edge of the second joint is a little less pronounced and does not reach quite so far.

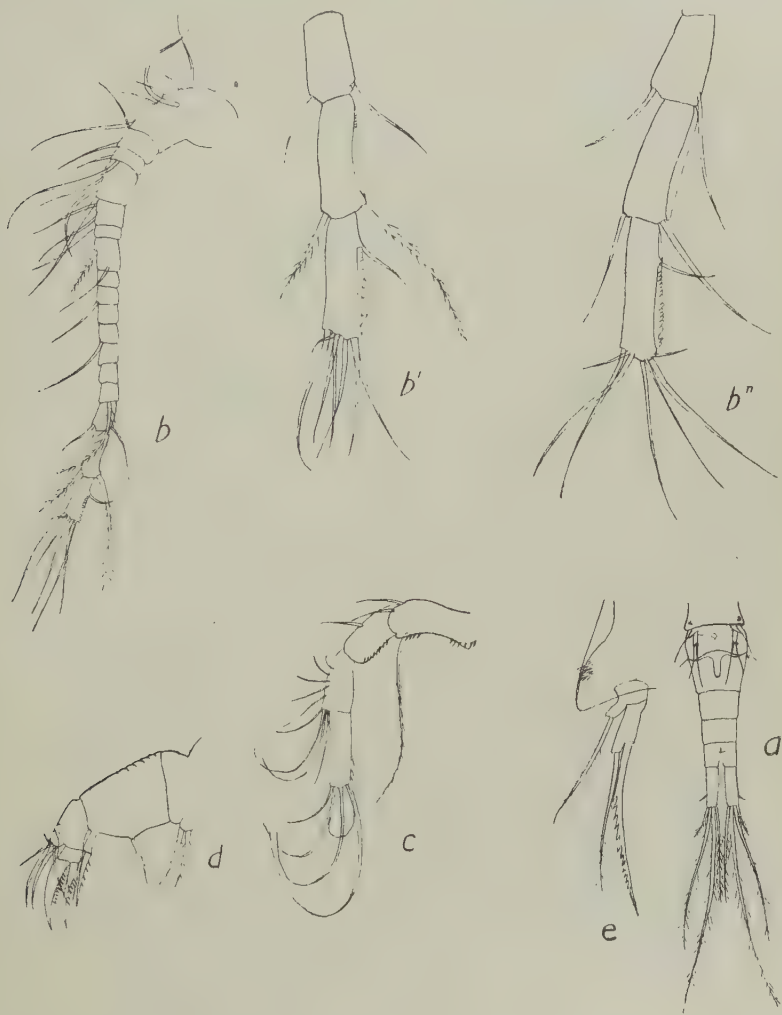


FIG. 7.—*Mesocyclops meridianus* Kiefer. *a*. Tail, female. *b*. Anterior antenna, female. *b'*, *b''*. Anterior antenna, female, joints 15-17 showing variation. *c*. Posterior antenna, female. *d*. Anterior maxilliped, female. *e*. Leg 5, female.

The swimming feet have the typical spine formula, but are at once distinguished from the type-species by the fact that none of the outer edges of the outer rami in any of the four pairs of feet bear denticulations. The first swimming foot bears a seta at the inner corner of its second basal joint.

In some specimens this seta may be very stout or practically spinous (fig. 8, *c*). In the second foot the spines are much stouter.

In the fourth foot (fig. 8, *d*) the outer ramus is stouter than in the type-species, while the inner ramus is practically identical, being longer than the

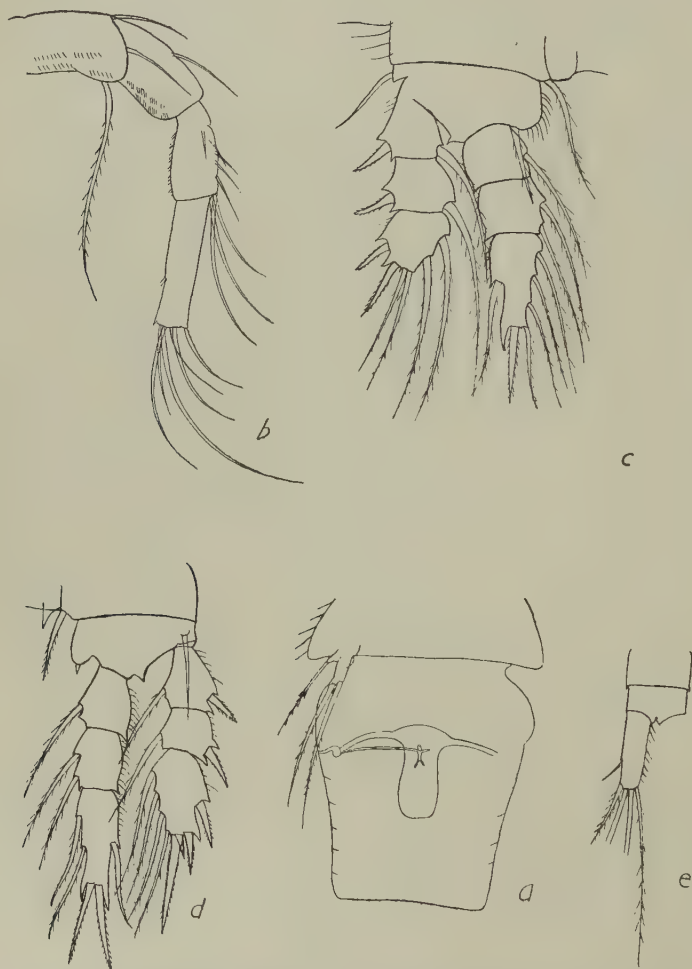


FIG. 8.—*Mesocyclops meridianus* Kiefer. *a*. Genital segment and leg 5, female (showing variation). *b*. Posterior antenna, female (showing variation). *c*. Leg 1, female. *d*. Leg 4, female. *e*. Caudal ramus, female.

outer with the 3rd joint somewhat attenuated, and bearing two subequal terminal spines. The connecting lamella may bear a prominent tooth on either side, but these may be absent. The dimensions of the terminal joint of the inner ramus of the fourth swimming foot are given in the table,

The *fifth swimming foot* is practically identical with that of the type-species, but it is very variable. The inner seta of the second joint may be quite stout and bear coarse teeth, or it may be quite fine and smooth (figs. 7 *e* & 8 *a*).

The seminal receptacle is quite different from the type-species, consisting of a single tongue-shaped organ. It is very little extended in front, but its structure varies considerably.

REMARKS.—The species is very variable, and during my investigation I described and figured it as no less than four separate species. Further consideration has, however, convinced me that it is not possible to separate it in this way, since all the various characteristics overlap and every gradation occurs among most of the samples. I think there can be no doubt that the species should be referred to *Mesocyclops meridianus* Kiefer.

The species is very common and occurred in seventeen out of the thirty-seven samples.

MESOCYCLOPS TENUIS Marsh.

Syn. *Cyclops tenuis* Marsh, A Revision of the North American Species of *Cyclops*
Dwight Marsh, 1910.

The following dimensions (in millimetres) were obtained from a typical adult female specimen :—

Length (exclusive of setae)	1.0
Length of trunk .....	.63
" tail .....	.37
" cephalic segment .....	.35
" genital segment .....	.14
" last three tail segments .....	.14
" caudal rami .....	.09
" inner apical seta .....	.30
" outer apical seta .....	.22
" inner corner seta .....	.18
" outer corner seta .....	.04
" dorsal seta .....	.12
Width of cephalic segment .....	.29
Greatest width of genital segment .....	.12
Least width of caudal rami .....	.02
Fourth swimming foot, inner ramus, terminal joint :	
Length of joint .....	.064
Greatest width of joint .....	.020
Length of inner terminal spine .....	.068
" outer terminal spine .....	.036

DESCRIPTION.—Both the trunk and the tail are decidedly attenuated, reminding one of the well-known European species *Mesocyclops oithonoides* G. O. Sars. The ratios of the various parts can be seen by reference to the above table. The last thoracic segment is quite narrow, being narrower even than the base of the genital segment. The genital segment (fig. 9, *a*) is narrow and somewhat elongated, but it is only slightly longer than its greatest breadth,

while its length is equal to that of the last three tail segments. The genital segment bears a lateral seta. The seminal receptacle is difficult to make out in the preserved specimens, but after staining, its appearance is as in the figure. The caudal rami are not divergent. They are about four and a half times as long as their least breadth. Their inner margins bear no hairs. The lateral seta occurs at the mid-point of the rami. The dorsal setae are long.

The anterior antennae reach back as far as the hinder edge of the second trunk segment. They are 17-jointed and the last two joints bear a very

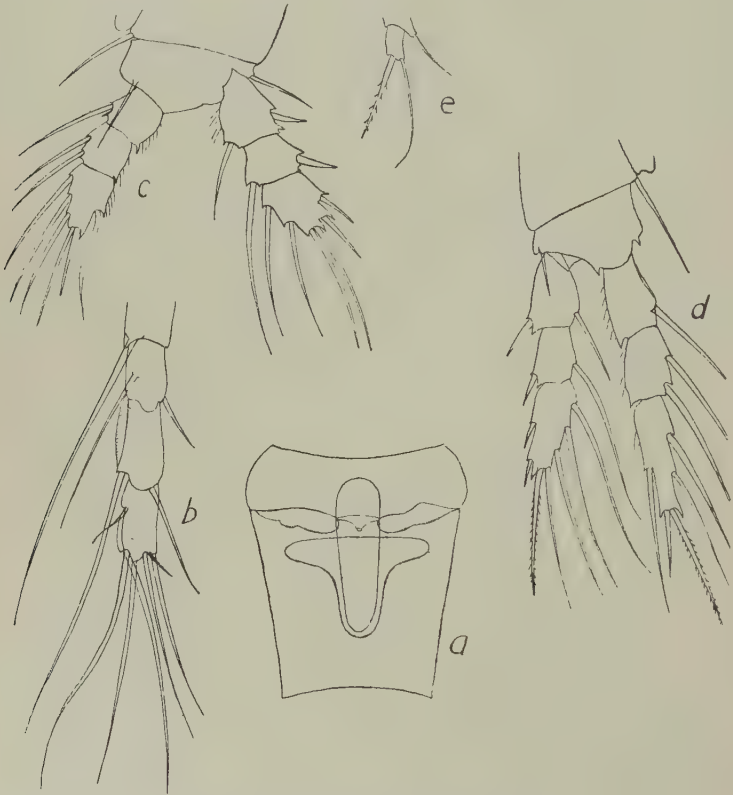


FIG. 9.—*Mesocyclops tenuis* Marsh. a. Genital segment, female. b. Last three joints of anterior antenna, female. c. Leg 1, female. d. Leg 4, female. e. Leg 5, female.

definite hyaline membrane. This membrane extends the whole length of the sixteenth segment, but it is not to be traced in the proximal half of the seventeenth segment (fig. 9, b).

The first swimming foot has both rami relatively short compared with the other feet. The inner corner of the second basal segment bears a long seta. None of the spines are strong or noticeably toothed (fig. 9, c).

The fourth swimming foot has its inner ramus decidedly elongated. The connecting lamella bears rounded processes, but no teeth (fig. 9, *d*).

The relative length of the terminal spines to each other and to the joint are given by the table of dimensions, and they are figured. The outer terminal seta is much finer than the inner and is smooth, while the latter is coarsely toothed. These constitute one of the chief distinctions between this species and *M. oithonoides*.

The fifth foot consists, of course, of two joints. The second joint bears at its inner corner a very definite spinous process with rather coarse teeth as shown in the figure (fig. 9, *e*). There are no crenulations on the posterior edge of the basal part of the anterior maxillipeds. Spine formula of the swimming feet is 2.3.3.3.

REMARKS.—I think there is no doubt that this is the species that Dwight Marsh has recorded both from Arizona and Panama, though in his specimens there is no hyaline membrane on the last joints of the anterior antennae. The species certainly cannot be referred to *M. oithonoides* G. O. Sars, as it differs in several points. It is far less attenuated. The seminal receptacle is quite different and so are the dimensions of the fourth swimming foot.

The species occurred in four out of the thirty-seven samples examined.

MESOCYCLOPS MINUTUS, sp. n.

Length of adult female .6–.65 mm.

The tail segments are attenuated, especially the first or genital segment.

The caudal rami are from two to three times as long as broad and bear quite characteristic terminal setae. Both are remarkably short, being little more than three times the length of the rami. The inner terminal seta is expanded towards its distal end as shown in the figure (fig. 10, *a*). The inner corner seta is about the length of the ramus, while the outer seta is less than half the length of the ramus.

The swimming feet are all three-jointed. The terminal joint of the inner ramus of the fourth swimming foot is not much elongated. It bears terminally one minute spine and one much longer (fig. 10, *b*). Of the terminal spines the outer is minute, while the inner is much longer and conspicuously bent.

The antennules are 17-jointed and reach to the distal edge of the second cephalic segment. The 16th joint is longer than the 17th. The latter joint bears a hyaline membrane, which is quite smooth. The fifth foot (fig. 10, *c*) is two-jointed, the second joint being decidedly elongated. Shape of the seminal receptacle could not be determined.

DIAGNOSIS.—The minute size coupled with the very characteristic terminal setae on the caudal rami at once distinguish this species from any other in the genus.

REMARKS.—Only two or three specimens were obtained of this rather remarkable species, and they were found in the one sample only.

LEPTOCYCLOPS NEWMANI Pesta.

This was the only species of *Leptocyclops* found in the whole collection. Very few specimens were obtained and they occurred in one sample only.

PLATYCYCLOPS POPPEI Rehberg.

A few specimens of this species were obtained from one of the samples. It is a perfectly well-known species occurring in the British Isles and recorded from Europe generally. It is also recorded from South Africa.

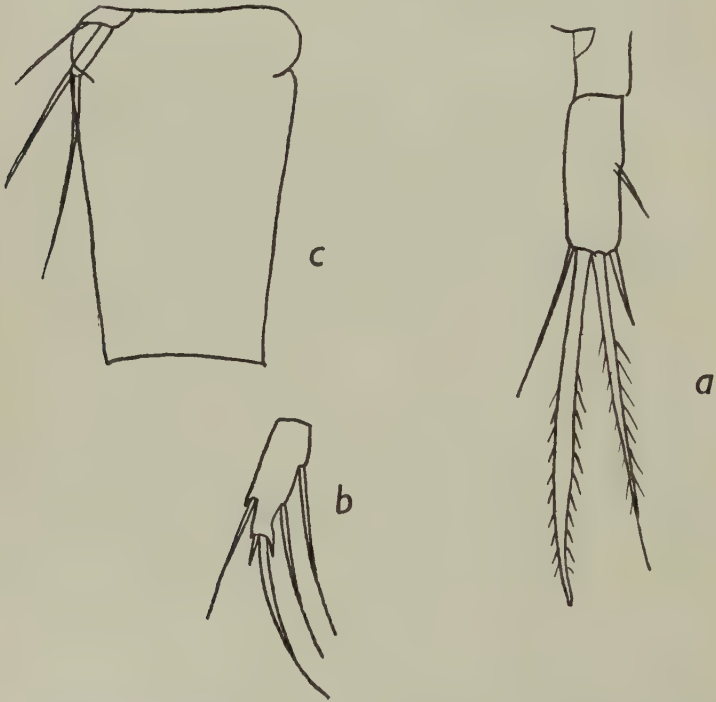


FIG. 10.—*Mesocyclops minutus*, sp. n. a. Caudal ramus, female. b. Leg 4, joint 3, inner ramus, female. c. Genital segment and leg 5, female.

PLATYCYCLOPS RUBESCENS Brady.

Syn. *Ectocyclops rubescens* Brady.

Only a few specimens of this interesting species were found. According to Kiefer (11) the species is only a synonym of *P. phaleratus* Koch. In my opinion it is a perfectly distinct species, easily distinguished among other features by structure of the anterior antennae. I have discussed the matter at some length in my description of the freshwater copepods of Abyssinia (Lowndes, 13). Identical specimens were obtained from Abyssinia, while the species was first recorded from Natal.

CRYPTOCYCLOPS VARICANS Sars.

Specimens of this well-known species were obtained from several samples, and the most careful measurements failed to detect any difference between them and the British specimens. The occurrence of this species here constitutes an important example of the almost cosmopolitan distribution of so many of the well-known species of *Cyclops*.

CRYPTOCYCLOPS ANCEPS Richard.

Syn. *Cyclops anceps* Richard, Entomostraca de l'Amérique du Sud, Mém. Soc. Zool. de France, Tome x (1897).

Cyclops anceps Daday, Süßwasser-Mikrofauna Paraguays, Zoologica, Heft 44 (Stuttgart, 1905).

Cyclops quinquepartitus Dwight Marsh, Report on the Freshwater Copepoda from Panama, Smithsonian Miscellaneous Collections, vol. lxi, no. 3 (1913).

Measurements taken in millimetres from adult females :—

	1.	2.	3.	4.	5.
Length (exclusive of setae)	·89	9	1·06	1·1	1·02
Length of trunk	·54	6	·68	·69	..
„ tail	·35	3	·38	..	..
„ cephalic segment	·30	..	·38	..	..
„ genital segment	·12	..	·12	..	..
„ last three tail segments	·16	..	·14	·168	..
„ caudal rami	·076	·08	·11	·08	·096
„ inner apical seta	·33	·32	·42	·35	·40
„ outer apical seta	·23	·24	·28	·26	·27
„ inner corner seta	·072	·084	·088	·072	·088
„ outer corner seta	·046	·052	·044	·052	·052
Width of cephalic segment	·30	..	·39	·36	..
„ 4th trunk segment	·14	..	..	..	..
Greatest width of genital segment	·10	..	·12	..	..
Least width of caudal rami	·022	·018	·024	·022	·02

P. 4.

	1.	2.	3.	4.	5.
Length	·076	..	·096	·092	·088
Width	·032	..	·032	..	·032
Inner terminal spine	·060	..	·072	·060	·068
Outer terminal spine	·04	..	·050	·052	·050

DESCRIPTION.—The trunk is moderately robust, since the cephalic segment is as long as it is broad, but the tail is definitely attenuated. The last thoracic segment is somewhat angular in outline and bears on either side a fairly long seta (figs. 11, *a* & *b*). The genital segment is definitely shorter than the last three segments combined. The tail segments are usually elongated, but specimens occur in which they appear definitely broader than they are long (fig. 11, *c*, *c'*, *c''*).

The caudal rami are from three to five times as long as they are broad with their inner edges smooth (fig. 11, *d*, *d'*).

The apical seta are long and close together. Their length seems to vary, but the inner seta is never much shorter than the tail. The inner corner seta is about the length of the caudal rami, but reference to actual measurements will show that it may be slightly longer, but more generally it is slightly shorter. The outer corner seta also varies, but it is always considerably shorter than the inner corner seta and also the rami. There are minute spinules surrounding the base of the rami themselves and also the base of the outer corner seta (fig. 11, *d''*). The seminal receptacle varies considerably in shape as shown by the drawings (fig. 11, *c'* & *c''*).

Appendages.—The anterior antennae are comparatively long for the genus, though they never reach back as far as the edge of the cephalic segment. It is very difficult to get exact measurements of the segments, but two sets of measurements are given below :—

20	5	2.5	7	5	2	7	13	11	7	9	9
1	2	3	4	5	6	7	8	9	10	11	12
15	4	3	5	4	2	6	10	9	6	7	7
1	2	3	4	5	6	7	8	9	10	11	12

These measurements at least show that the 8th and 9th joints are the longest, except for the 1st. The 6th joint is the shortest, while the last three joints are comparatively long. The appendages are well supplied with setae, those on the 4th and 9th joints being conspicuous (fig. 11, *e* & *e'*).

Posterior antennae.—The outer margin of the 3rd joint is markedly serrated and well supplied with setae. There are 10 setae along this edge altogether (fig. 11, *f*).

Anterior maxilliped.—The claw of the 3rd joint bears some coarse teeth. The nature of these teeth varies considerably, but in this species the distal tooth is definitely larger than the others. Sometimes the other teeth are successively smaller, but in other specimens only the distal tooth may be conspicuous (fig. 11, *g*, *g'*, *g''*). The teeth are quite different from those of the type-species *Cryptocyclops varicans* Sars.

The posterior maxillipeds are typical.

Swimming feet.—Spine formula 3.4.4.3.

All four pairs of teeth are, of course, two-jointed in both their rami.

There is no seta or spine on the inner corner of the basal joint of the first swimming foot. There is a stout terminal spine on the 2nd joint of the inner ramus (fig. 11, *h* & *h'*). The 2nd and 3rd feet are identical. The spines are much coarser than those on the 1st or 4th foot.

Fourth foot.—The measurements of the 2nd joint of the inner ramus are given in the special table (p. 115). In all cases measured the inner spine was definitely longer than the outer, though in no case was the outer as short as half the inner. On the surface of the 2nd joint there are some rather conspicuous setae, as shown in the drawing (fig. 11, *k* & *k'*). This seems to constitute a useful



FIG. 11.—*Cryptocyclops anceps* Richard. *a*. Dorsal view, female. *b*. Dorsal view, female, variety. *c*, *c'*, *c''*. Genital segment and leg 5, female (showing variation). *d*, *d'*. Caudal rami and last two tail segments, female (showing variation). *d''*. Distal corner of caudal ramus, enlarged. *e*, *e'*. Anterior antenna, female. *f*. Posterior antenna, female. *g*, *g'*, *g''*. Anterior maxilliped, female. *h*, *h'*. Leg 1, female. *k*, *k'*. Leg 4, female. *l*. Leg 5, female.

characteristic. These setæ are present to some extent also in the same joint of the 2nd and 3rd feet, but are wanting on the 1st foot.

The 5th foot is somewhat characteristic. It is reduced to a single joint bearing a long terminal seta and a conspicuous spine on its inner edge. This spine is sometimes wanting in the type-species, but apparently it is always present in this species (fig. 11, *c* & *l*).

REMARKS.—The table of measurements (p. 115) will show how very variable the species is, and in my preliminary investigation I described and figured no less than four separate species including *Cyclops anceps* Richard and *Cyclops dentatimanus* Dwight Marsh, but further investigation has convinced me that they are all one and the same species. No specimens examined agree exactly with the species first described by Richard in which the outer corner seta is definitely longer than the inner. In all the specimens examined the inner corner seta is definitely longer than the outer. Again, the terminal spines of the 2nd joint of the outer ramus of the 4th foot are subequal in Richard's species, while they quite definitely are not so in the specimens examined here. Dwight Marsh separated his species *C. dentatimanus* on the nature of the teeth of the claw on the 3rd joint of the anterior maxilliped. While the presence of these teeth quite clearly separates *C. anceps* and *C. dentatimanus* from the type-species, they are far too variable to separate the two South American species. All the South American specimens here included agree in the following characteristics :—

1. The absence of a seta on the inner corner of the basal joint in P. 1.
2. The presence of definite teeth on the claw of the anterior maxilliped.
3. The presence of hairs or setae on the face of the 2nd joint of the inner ramus of the swimming feet 2, 3, and 4.
4. The structure of P. 5.
5. The shape of the seminal receptacle.

A large number of specimens were obtained and the species was found in seventeen out of the thirty-seven samples examined.

CRYPTOCYCLOPS MENDOCINUS Wierzejski.

Syn. *Cyclops mendocinus* Wierz.

The following table gives the chief measurements (in millimetres) and ratios of the various parts of this species. They were all taken from a dead and preserved specimen that appeared to be without distortion of any kind :—

ADULT FEMALE.

Length (exclusive of setae)	·94
Length of trunk	·59
„ tail	·35
„ cephalic segment	·36
„ genital segment	·14
„ last three tail segments	·13
„ caudal rami (least length)	·10

Length of inner apical seta	·22
„ outer apical seta	·20
„ inner corner seta	·04
„ outer corner seta	·06
„ last two segments	·08
Fourth swimming foot, inner ramus:	
Length of terminal joint	·06
Width of terminal joint (greatest)	·028
Length of inner terminal seta	·072
„ outer terminal seta	·034
<i>Ratios.</i> —Trunk : tail	1·55 : 1
Cephalic segment : next four segments	1·56 : 1
Cephalic segment, width : breadth	1 : 1
Trunk, length : width	1·64 : 1
Genital segment, length : width	1 : 1
Genital segment, length : following segments	1·1 : 1
Caudal rami, length : least width	5·0 : 1
length : I.C.S.	2·5 : 1
length : O.C.S.	1·68 : 1
Length of I.C.S. : O.C.S.	·66 : 1
Longer apical seta : tail	·63 : 1

DESCRIPTION.—In general appearance the animal is normal, being neither attenuated nor robust, while the length of the trunk is about half as long again as the tail. The cephalic segment has an evenly rounded or oval appearance in front, and the greatest width of the trunk lies at the posterior edge of this segment. The second and third body segments are rather expanded laterally, and the posterior edge of the third segment forms a rather conspicuous point on either side.

The posterior edge of the fourth segment is more rounded laterally. The fifth segment is much narrower and bears on either side a conspicuous seta or spine pointing directly outwards. The genital segment is as long as it is broad and tapers gradually behind giving rather a stumpy appearance (fig. 12, *a*). The anal segment is rather elongated, being nearly twice the length of the previous segment. Its least width is some distance away from the edge of the caudal rami, since it widens out distally. Its posterior edge does not bear spinules (fig. 12, *b*). The rami are five times as long as broad and they are slightly divergent. There are no setae or hairs along their inner edge. The lateral setae are small and occur rather more than halfway along the rami.

Of the apical setae the terminal ones are short and stout and practically equal.

The inner corner setae are slightly shorter and much finer than the outer corner setae. The outer corner setae are much shorter than the rami.

The seminal receptacle is not easily seen in preserved specimens without staining. Its appearance is that shown in the accompanying figure (fig. 12, *a*, p. 120).

The *anterior antennae* are twelve-jointed and reach back to the edge of the cephalic segment. The 5th joint is very short, while the 7th is conspicuously

long. There are many conspicuous setae present, while that on the third segment reaches practically to the distal edge of the ninth (fig. 12, *c*).

The posterior antennae appear to be fairly normal. 3rd joint bears six setae (fig. 12, *d*).

The masticatory lobe of the maxilla is well marked and bears some remarkably strong teeth, which are quite conspicuous even without dissection (fig. 12, *e*).

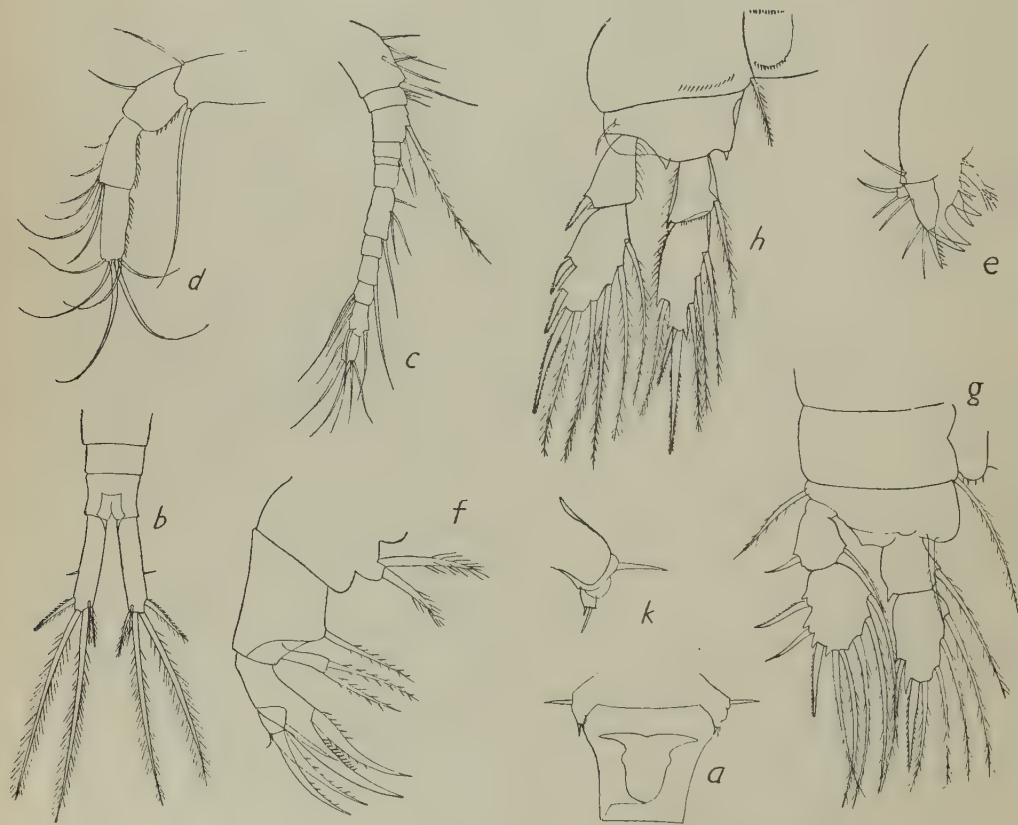


FIG. 12.—*Cryptocyclops mendocinus* Wierzejski. *a*. Genital segment, female. *b*. Caudal rami, female. *c*. Anterior antenna, female. *d*. Posterior antenna, female. *e*. Maxilla, female. *f*. Anterior maxilliped, female. *g*. Leg 1, female. *h*. Leg 4, female. *k*. Leg 5, female.

The anterior maxilliped bears on its terminal joint the usual setae, but two of them are much larger than usual. This also applies to the spine which articulates with the characteristic claw of the 3rd joint, with the result that the claw appears much less prominent than usual. The two plumose setae on the 1st joint are also rather exceptionally broad (fig. 12, *f*).

The *swimming feet* are, of course, biarticulate in both rami. The spine formula is 3.4.4.3.

In P. 1 the terminal joint of the outer ramus is broad, and there is a well-marked reflexed seta on the inner corner of the 2nd basal joint (fig. 12, *g*). In the 4th swimming foot the proximal joints of both rami are rather elongated. The 1st joint of the inner ramus has its lateral edges curled over considerably. The connecting lamella of the first three pairs of swimming feet bear on either side rounded protuberances: these processes bear about four minute spinules. The connecting lamella of the 4th foot does not show these rounded protuberances (fig. 12, *h*).

The 5th *swimming foot* is one-jointed only, but that joint is quite well defined. On its inner corner it bears a very short spinule, while that of the outer corner is quite twice as long (fig. 12, *k*).

The *ovisacs* are rather large, but contain only a few eggs.

DIAGNOSIS.—The reduced number of joints in the anterior antennae, the biarticulation of both rami of all the swimming feet together with the vestigial nature of the 5th swimming foot at once reduces this species to the one genus *Cryptocyclops*, and of this genus there is no other with 12 joints to the antennae with the subequal and short apical setae.

REMARKS.—Specimens were not very abundant, and the species is only recorded from four of the thirty-seven samples.

CRYPTOCYCLOPS ELONGATUS, sp. n.

The following measurements (in millimetres) were taken from a typical adult female :—

Length (exclusive of setae)	1.0
Length of trunk .....	.62
" tail .....	.38
" cephalic segment .....	.4
" genital segment .....	.12
" last three tail segments .....	.14
" caudal rami .....	.14
" inner apical seta .....	.36
" outer apical seta .....	.26
" inner corner seta .....	.076
" outer corner seta .....	.036
Width of cephalic segment .....	.36
" genital segment (greatest) .....	.140
Least width of caudal rami .....	.024
P. 4, R. 1, terminal joint.	
Length of joint .....	.088
Width .....	.032
Inner terminal seta .....	.048
Outer terminal seta .....	.028

In general appearance this species is closely allied to *Cryptocyclops anceps* Richards, but differs in several respects. The anterior antennae are 12-jointed, but are only three-quarters the length of the first cephalic segment.

The posterior antennae are typical, while the anterior maxillipeds bear no conspicuous teeth on the claw of the 3rd joint.

The caudal rami are considerably elongated, being from five to six times as long as they are broad. The inner corner seta is about twice the length

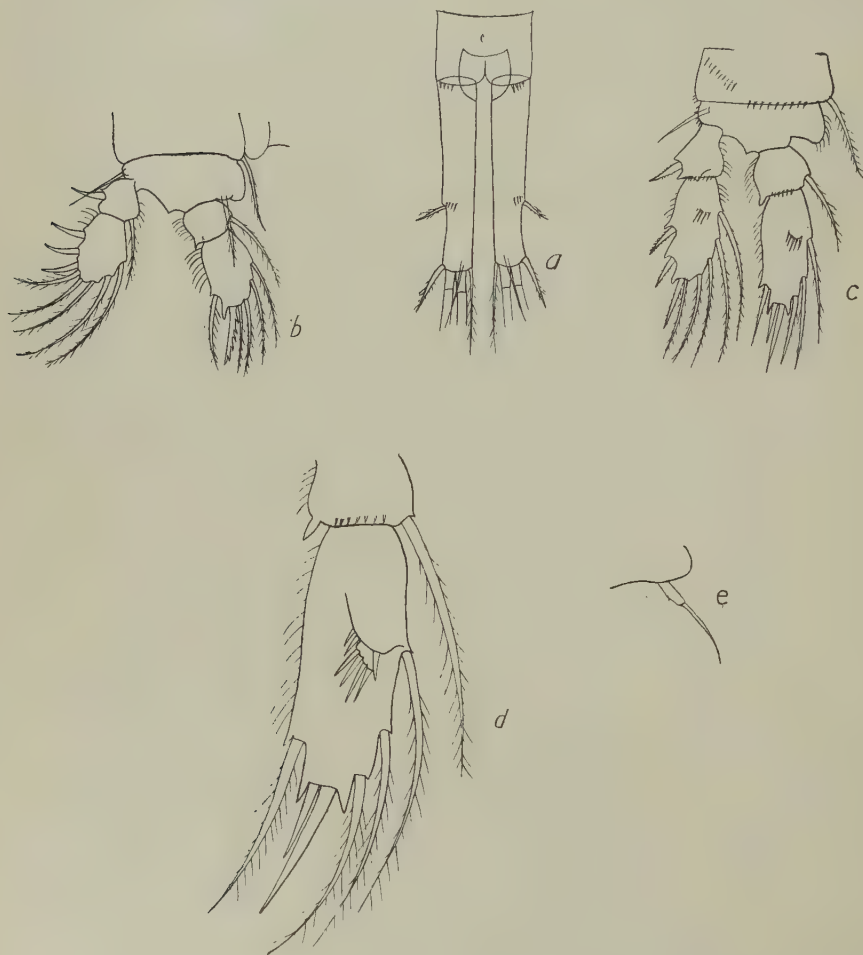


FIG. 13.—*Cryptocyclops elongatus*, sp. n. a. Caudal rami, female. b. Leg 1, female. c. Leg 4, female. d. Leg 4, terminal joint, inner ramus, female. e. Fifth foot, female.

of the outer corner seta and little over half the length of the ramus. The lateral seta occurs two-thirds the distance along the outer edge of the ramus, and just above its base there is a row of spinules which run halfway across the rami both on their dorsal and ventral surfaces (fig. 13, a).

Swimming feet.—There is a well-marked seta on the inner corner of the 2nd basal joint of the 1st swimming foot.

The spines on the outer edges of the swimming feet are rather fine and the serrations are inconspicuous.

On the surface of the terminal joint of the inner ramus of the 2nd, 3rd, and 4th feet there is a definite scale bearing some elongated spinules or setae (fig. 13, *c*). The length of the joint in the 4th foot is over twice the width, while the longest seta is nearly twice the length of the shorter. The two terminal spines appear to be almost smooth (fig. 13, *d*). The 5th foot consists of a single elongated joint bearing a terminal seta and an extremely fine spinule on the inner edge of the joint about its mid-point (fig. 13, *e*).

REMARKS.—Only a few specimens were obtained of this species and they all came from the one sample.

CRYPTOCYCLOPS TREDECIMUS, sp. n.

Three adult females gave the following measurements (in millimetres):—

	1.	2.	3.
Length (exclusive of setae)	·71	·86	·75
Colour.....			
Length of trunk	·46	..	..
" tail	·25	..	..
" cephalic segment	·26	..	..
" genital segment	·104	..	..
" last three tail segments	·092	·092	..
" caudal rami	·068	·10	·068
" inner apical seta	·18	·184	·20
" outer apical seta.....	·16	·168	·16
" inner corner seta	·036	·032	·04
" outer corner seta	·044	·048	·048
Width of cephalic segment	·25	·30	·27
" 4th trunk segment .....	..	..	..
Greatest width of genital segment....	·104	·12	..
Least width of caudal rami	·02	·024	·02
P. 4.			
Length	·054	·054	·056
Width	·024	·032	·026
Inner terminal spine	·04	·048	·048
Outer terminal spine	·022	·024	·024

DESCRIPTION (fig. 14, *a*).—In general appearance this species closely resembles the European species *Cryptocyclops bicolor* Sars in its size and caudal rami bearing short subequal terminal setae, but dissection shows the species to be perfectly distinct. The caudal rami are about four times as long as broad, while the lateral seta is much nearer the middle than in *C. bicolor*: actually it occurs just less than two-thirds the distance along the outer edge of the rami (fig. 14, *b*).

The inner edges of the rami are smooth.

Of the setae the two terminals are short and subequal, while the outer corner seta is definitely longer than the inner, but the former is considerably shorter than the rami.

The genital segment is rather broad at its base and usually longer than the three succeeding segments taken together. The seminal receptacle is very difficult to make out, but it seems to extend almost to the base of the genital segment (fig. 14, *c*).

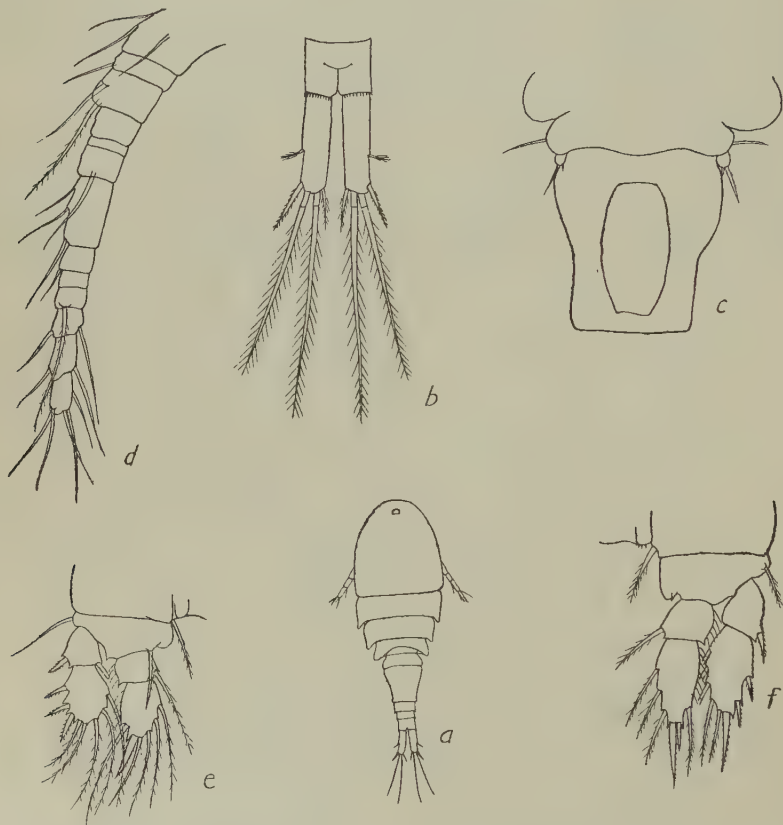


FIG. 14.—*Cryptocyclops tredecimus*, sp. n. *a.* Dorsal view, female. *b.* Caudal rami, female. *c.* Genital segment, female. *d.* Anterior antenna, female. *e.* Leg 1, female. *f.* Leg 4, female.

Appendages.—The anterior antennae are relatively long and extend well beyond the edge of the first cephalic segment. They are 13-jointed, thus differing from those of any other species of the genus. The 7th joint is much the longest (fig. 14, *d*).

The posterior antennae are typical.

There are no conspicuous teeth on the claw of the 3rd joint of the anterior maxilliped, while the posterior maxilliped is typical.

Swimming feet.—Both rami of all four pairs are, of course, only two-jointed. Spine formula 3.4.4.3.

There is a well-developed seta on the inner corner of the basal joint of the 1st swimming foot. The spines on the outer edge of the outer ramus are not coarse, and the teeth are also rather unusually fine (fig. 14, *e'*).

The teeth are only slightly coarser on the 2nd and 3rd swimming feet.

The measurements for the 2nd joint of the inner ramus of the 4th foot are given in the table (p. 123), when it will be seen that inner terminal seta is always slightly shorter than the joint, while it is almost exactly twice the length of the outer terminal seta. The longer seta is also decidedly the stouter. The connecting lamella bears a few teeth as shown in the drawing (fig. 14, *b*). The 5th foot is single-jointed. The joint in question is somewhat rounded and bears a long seta and a short but fairly pronounced spine (fig. 14, *c*).

REMARKS.—Specimens were fairly abundant. The species is recorded from three of the samples.

CRYPTOCYCLOPS BREVIFURCA, sp. n.

A typical adult female gave the following dimensions (in millimetres):—

Length (exclusive of setae)	·75
Length of body	·25
" tail	·125
" genital segment	·12
" last three segments	·084
" caudal rami	·048
" inner corner seta	·088
" inner terminal seta	·172
" outer terminal seta	·164
" outer corner seta	·08
Greatest width of cephalic segment	·29
Least width of caudal rami	·024
Greatest width of genital segment	·10
P. 4, R. 4, terminal joint and setae.	
Length of joint	·050
Width	·024
Inner terminal seta	·054
Outer terminal seta	·020

DESCRIPTION.—This is a small and compact species, resembling in appearance *Cryptocyclops varicans* Sars, though the tail is shorter, being only half the length of the trunk.

The genital segment is longer than the next three segments combined, and it is as long as it is broad (fig. 15, *a*). The caudal rami are short and stout, being not more than twice as long as broad and only as long as the anal segment. Their inner margins are devoid of hairs (fig. 15, *b*).

The inner corner seta is slightly longer than the outer, while both are about twice the length of the rami. The outer corner seta is not at all spinous.

The lateral seta is long and occurs at a distance about two-thirds along the outer edge of the ramus. The dorsal seta is comparatively long.

The apical setae are subequal and comparatively short. The anterior antennae are 10-jointed and do not reach to the margin of the cephalic segment (fig. 15, c).

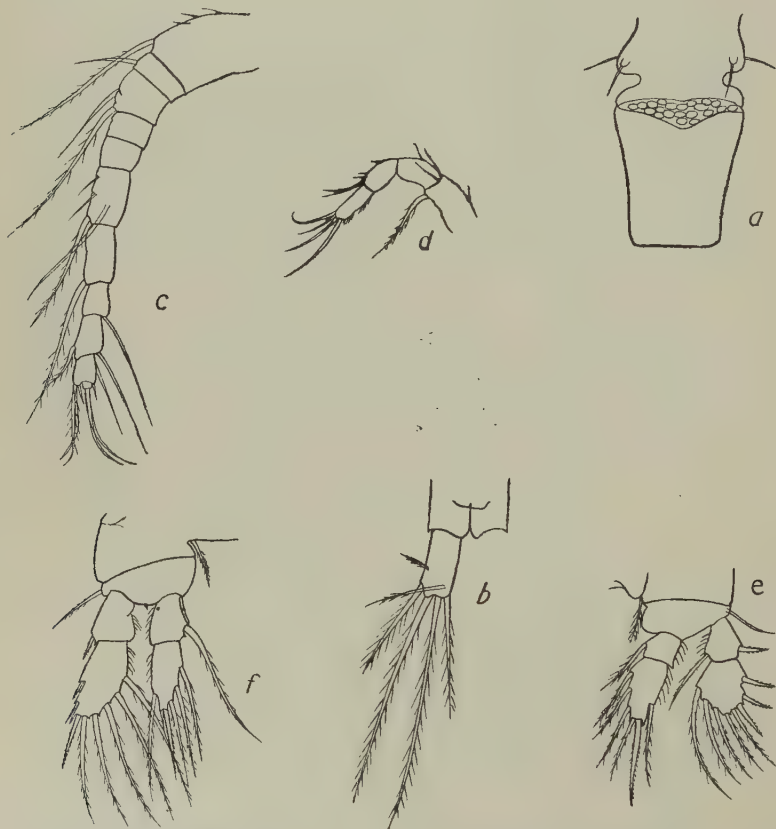


FIG. 15.—*Cryptocyclops brevifurca*, sp. n. a. Genital segment, female. b. Caudal rami, female. c. Anterior antenna, female. d. Posterior antenna, female. e. Leg 1, female. f. Leg 4, female.

The posterior antennae have the 4th joint rather elongated, while the setae on the 3rd joint are reduced in number (fig. 15, d). The maxillipeds are typical.

Swimming feet.—The basal joint of P. 1 bears no seta on its inner corner. The terminal joint of the outer ramus is broad, but the spines are comparatively slender,

The terminal spine of the last joint of the inner ramus is rather longer than the joint itself (fig. 15, *e*). The spines of P. 2 and P. 3 are much stouter than those of P. 1, P. 4. The length of the terminal joint of the inner ramus has been given above (fig. 15, *f*).

Spine formula 3.4.4.3.

Fifth foot.—This is reduced to a small knob bearing a single seta.

Seminal receptacle.—This is difficult to make out in the preserved specimens, but its outline is more or less shown in the figure.

DIAGNOSIS.—The length of the caudal rami with their setae etc. and the 10-jointed antennae separate this from all other species of the genus.

REMARKS.—Only a few specimens were found and they all came from the one sample.

CRYPTOCYCLOPS LATICORNIS, sp. n.

The following dimensions (in millimetres) were obtained as the average from a number of adult females :—

Length exclusive of setae	1.1
Length of caudal rami .....	.064
„ inner apical seta .....	.256
„ outer apical seta .....	.204
„ inner corner seta .....	.036
„ outer corner seta .....	.052
Least width of caudal rami .....	.032
Terminal joint of the inner ramus of the fourth swimming foot gave :—	
Length of joint .....	.084
Width (greatest) .....	.030
Inner terminal seta .....	.052
Outer terminal seta .....	.028

GENERAL DESCRIPTION.—The species is very definitely a *Cryptocyclops*, having all its four pairs of swimming feet two-jointed, a somewhat reduced 5th foot, and shortened antennae with only twelve joints.

The species is really closely related to *Cryptocyclops mendocinus* Wierzejski, though it differs in several points. The caudal rami are quite short, being only twice as long as broad and scarcely exceeding in length the anal segment (fig. 16, *a*). There is little or no essential difference in the 5th swimming foot or the anterior antennae, though the latter are shorter in this species and stouter. The relative lengths of the joints are the same in both species.

The anterior maxillipeds show some difference in structure, for the 1st joint bears two long setae, as shown in the drawing, while the claw-like process of the 3rd joint is characteristically bent on its inner edge and bears much coarser teeth especially towards its extremity (fig. 16, *b*).

The other appendage of the same joint, which in *C. mendocinus* is stout and differing but slightly from the claw itself, is in this species replaced by a much

more slender process. The structure of the swimming feet is somewhat similar, but differs in detail. Thus the connecting lamella of the first pair of swimming feet bears two teeth only (fig. 16, *c*). The 4th swimming foot has the 2nd joint of the inner ramus much more elongated, while the relative length of the longer terminal spine to the joint is also different (fig. 16, *d*).

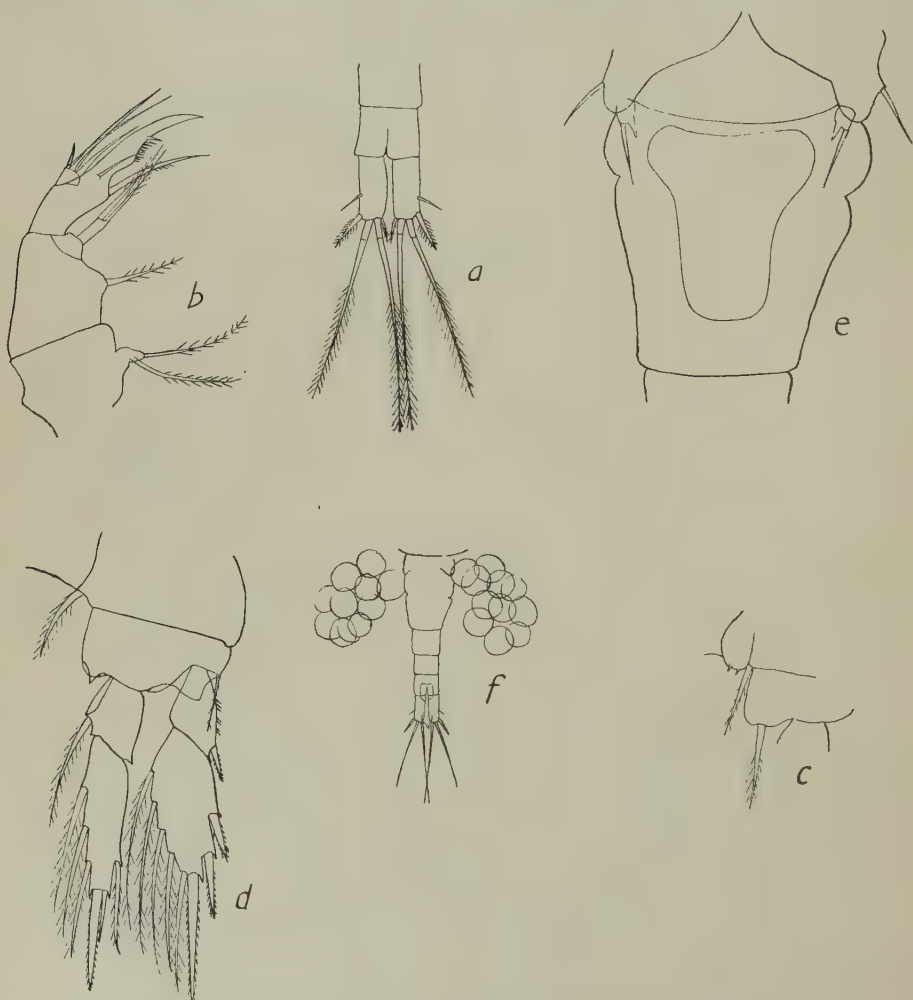


FIG. 16.—*Cryptocyclops laticornis*, sp. n. *a.* Caudal rami, female. *b.* Anterior maxilliped, female. *c.* Leg 1, basal joint and connecting lamella, female. *d.* Leg 4, female. *e.* Genital segment, female. *f.* Tail, female.

REMARKS.—Very few specimens were of obtained this species, and they all came from one sample.

CANTHOCAMPTUS RICHARDI, sp. n.

FEMALE.—Length .6–.7 mm.

Rostrum short and blunt. The cephalothorax with wavy ridge-like markings. The nuchal organ is elongated and slipper-shaped, apparently extending almost to the base of the rostrum (fig. 17, *a*).

Posterior margins of all the somites are serrated, except that of the first, which is smooth. Of the abdominal somites, nos. 1 and 2 are not separated

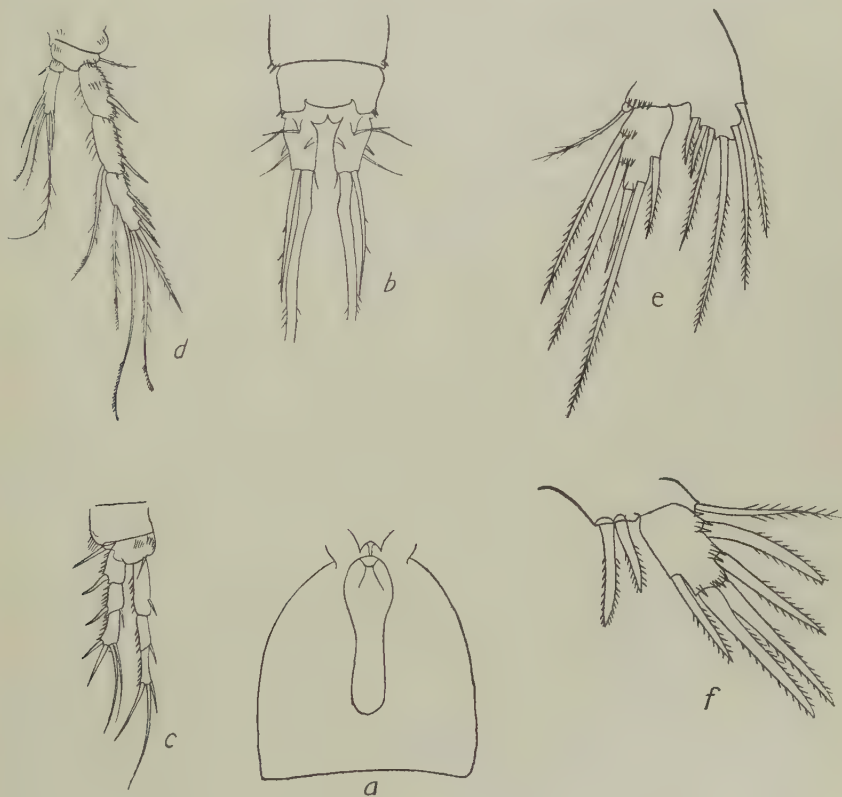


FIG. 17.—*Canthocamptus richardi*, sp. n. *a*. Cephalic segment, female. *b*. Caudal rami, female. *c*. Leg 1, female. *d*. Leg 4, female. *e*. Leg 5, female. *f*. Leg 5, male.

in any way. Somites 2, 3, and 4 bear laterally a series of small spines, but there are no spines on the mid-dorsal surface. The sides of the genital segment are lined with minute spinules. Somite 5 bears no spinules dorsally at the base of the caudal rami.

The edge of the operculum is supplied with minute spinules. Caudal rami rather narrow and tapering with two lateral setae and one spine in addition to the dorsal spine. The terminal setae are very different in size and length.

The inner seta is quite three times the length of the outer. It is thickened at its base and bent, as shown in the accompanying figure (fig. 17, *b*). The outer seta is much finer and straight. The inner seta is minute.

Under the high power the integument is seen to be covered all over with minute hairs.

The antennules are 8-jointed. The aesthete of segment 4 reaching to the end of segment 7. The exopod of the antenna is single-jointed and bears four setae.

Leg 1.—The endopodite is three-jointed. The 1st joint hardly exceeds in length the 1st and 2nd joints of the exopodite combined. The 2nd and 3rd joints are equal in length, and each is as long as the 3rd joint of the exopodite (fig. 17, *c*). In legs 2 and 3 the basis is produced between the rami to form a rounded knob, while the connecting lamella bears three spines on either side.

Leg 4.—The whole endopodite is no longer than the first joint of the exopodite. The terminal setae and those of the inner edge of the endopodite are tipped with combs of teeth (fig. 17, *d*).

Leg 5.—Segment 1 broad and somewhat produced with six strong setae, of which the 1st and 2nd are equal and quite short. The 4th spine is the longest. Segment 2 narrows distally. Its inner edge is quite smooth, while the outer edge bears spinules at the base of the spines only. The 1st and 2nd setae are strong and spinous with serrated edges. The third seta is short and not serrated. The 4th seta is the longest and is markedly serrated, while the 5th seta is much the shortest (fig. 17, *e*). The genital area possesses no special feature. There are two setae of markedly unequal length at the opening of the oviduct.

MALE.—Unfortunately only one male was found. The swimming feet showed the usual modifications, while the structure of the 5th foot is shown in the accompanying figure (fig. 17, *f*).

I think there can be no doubt that this is the species partly described by Richard (19), who drew the 5th foot of the male, but left the diagnosis of the species, and I therefore take this opportunity of naming this species after him.

REMARKS.—Several female specimens were obtained, and it is most unfortunate that only the one male was available. The species only occurred in two of the samples.

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Notes on the Linnean type-specimens of Flying-fishes (Exocoetidae). By ANTON FR. BRUUN, M.Sc., Copenhagen. (Papers from the *Dana* Oceanographical Collections, No. 2.) (Communicated by Dr. STANLEY KEMP, F.R.S., Sec.L.S.)

[Read 10 May 1934]

ALTHOUGH it has been known for a considerable length of time that two of Linné's types of Flying-fishes are still preserved (Lilljeborg 1891, Lönnberg 1896, Günther 1899, 1909), the bearing of these specimens on the confused state of nomenclature of the family has not been properly appreciated.

During a visit to London in September 1933 the present author had the opportunity of making some additional observations on the specimen of *Exocoetus exsiliens* L. preserved in the collections of the Linnean Society of London.

Information regarding some special characters of the type of *Exocoetus volitans* L., preserved in the Museum of the University of Uppsala, was received through correspondence with Professor N. von Hofsten and Dr. Tage Borgh of Uppsala, who kindly undertook the examination of these characters.

The author takes the opportunity of tendering his thanks to the Linnean Society of London for the facilities rendered by the Assistant Secretary, Mr. S. Savage, as well as to Professor N. von Hofsten and Dr. Tage Borgh for their ready assistance.

1. EXOCOETUS VOLITANS Linnaeus, 1758.

It must be admitted that the description given by Linnaeus (1758, p. 316) is not very satisfactory. Not even the generic character of the fish is clear, and opinions have differed as to whether the species had long or short ventrals, and as to their position in relation to the head and the tail.

Linnaeus himself certainly added to the confusion (1766, p. 521) in establishing another species, *Exocoetus evolans*. Linnaeus (loc. cit.) states:— 'Differt in paucis ab *E. volitante*, modo ea sufficient.'

It must suffice to state here that Lilljeborg (1891) and Lönnberg (1896) both conclude that the supposed difference is inadequate and that *E. evolans* L. should be regarded as a synonym of *E. volitans* L. Consequently, as pointed out by Lönnberg (1896), the generic name *Halocypselus* Weinland must give place to *Exocoetus* L.

Flying-fishes of the genus *Exocoetus* are by far the most common in the collections of the European Museums. Günther (1866) has shown the existence of a more common species, *Exocoetus volitans* L. [*E. evolans* L. of Günther], and a less common, *E. obtusirostris* Günther. The differences mentioned by Günther have not been accepted by all authors, but studies on the extensive material of the *Dana* collections have shown beyond doubt that he was right.

It has been found that the number of gill-rakers is an absolutely reliable character for distinguishing the two species. *E. volitans* has been found to have a total number of 29–37 gill-rakers, most commonly 32–34, whilst *E. obtusirostris* has 24–29, most commonly 26–27. This character has so far been found to be correlated with the number of transverse rows of scales between the beginning of the dorsal fin and the lateral line: there are six rows in *E. volitans* and seven in *E. obtusirostris*, the rudimentary ones along the dorsal not being counted.

E. volitans being by far the commoner species in the Atlantic, it was quite natural that Günther should give the new name to the species with seven transverse rows.

To exclude the possibility that the type of *E. volitans* was not really the same species as that called *E. evolans* L. by Günther, the author asked Professor N. von Hofsten to have some characters of the type re-examined. The examination was done by Dr. Tage Borgh, who, amongst other things, gave the number of gill-rakers as 30; the gill arch was not dissected out and the number may therefore be taken as a minimum.

E. volitans L. and *E. obtusirostris* Gthr. are thus two well-established species.

It may further be noted that a barbel on the chin has not been found in young stages of *E. obtusirostris*. Therefore, the species described by C. M. Breder (1928) as *E. obtusirostris* Gthr. must be either *E. monocirrhus* Richardson, *E. georgianus* Cuv. & Val., *E. borodini* (Nichols & Breder), or perhaps a species not hitherto recognized. These species, however, together with Breder's East-Pacific species should perhaps be regarded as races or subspecies.

2. EXOCOETUS EXSILIENS Linnaeus, 1771.

The third species of Flying-fish established by Linnaeus was (with his original spelling) *Exocoethus exsiliens*, dating from 1771. Published in a book entitled 'Mantissa plantarum,' most zoologists have failed to ascribe this species to Linnaeus. One of two exceptions seems to be Lilljeborg (1891), and his book is very little known outside Scandinavia, especially to students of Flying-fishes. It is more difficult to understand why Sherborn's correct citation (1902) should have been overlooked.

Jordan and Meek (1885) and previous authors generally cited Gmelin (1788) as the author. Jordan and Evermann (1896 *a*) find that the species had already been given by P. L. S. Müller (1776) as *E. exsiliens*, and therefore give this name preference of *E. exsiliens* Gmelin. Günther (1909) states that *E. exsiliens* Gmelin has priority over Müller's name, as the volume of Müller's edition of 'Systema naturae' with the description of the fish in question was dated 1789. This contradiction, which is now of less importance, is to be found in the fact that Günther used a second and later edition of Müller's work, which is still to be found in the Library of the British Museum (Natural History), and has been checked by the present author.

Jordan and Evermann (1896 *b*) have established a new genus, *Exonantes*, separated from *Cypsilurus* Swainson, 1838. As the type-species they give *E. exsiliens* P. L. S. Müller. The new genus is made to include all Flying-

fishes with long ventrals, placed behind the middle of the body, and with anal and dorsal fins at nearly the same vertical line. Most authors have recognized this division and no doubt whatever has arisen as to whether the conception of *E. exiliens* for this purpose was well founded. Recent authors (Breder 1928, Jordan, Evermann, and Clark, 1930, a.o.) all seem to have overlooked Günther's important redescription of Linnaeus's type.

As early as 1899 Günther mentioned this type-specimen, but it was not until 1909 that he fully realized its importance and made a very detailed investigation. The present author cannot add anything to this and confirms his careful examination. Yet the most important conclusion to be drawn from this, that *Exonantes* Jordan & Evermann becomes a synonym of *Cypsilurus* Swainson, appears to have been overlooked.

The Linnean specimen is half-grown and is still recognizable as a young specimen of the species generally known as *Cypsilurus nigricans* (Bennett) [= *E. bicolor* Cuv. & Val., *C. smithi* Breder & Nichols].

At least until more is known of the systematics of the Flying-fishes, it seems natural to follow Breder in dividing the Cypsilurinae into four genera (or sub-genera). *Exonantes* Jordan & Evermann, from the considerations above, being unavailable, the name *Danichthys* (nom. nov.) is proposed, with *Exocoetus rondeletii* Cuvier & Valenciennes (1846, p. 115, pl. 562) as the type-species of the genus.

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Deer in Ancient Egypt. By WARREN R. DAWSON, F.R.S.E.

(Communicated by Dr. STANLEY KEMP, F.R.S., Sec. L.S.)

(With 19 Text-figures)

[Read 12 April 1934]

THE occurrence amongst the ancient Egyptian monuments of pictures of stags is a matter of considerable interest, because deer are not, and almost certainly never have been, part of the fauna of the Nile Valley. Deer, both recent and fossil, are entirely lacking in the *Ethiopian Region* of zoological distribution, and also, with one exception to be noted below, in that part of the *Holarctic Region* that includes Northern Africa *. Yet deer were known to the ancient Egyptians, who have left us many pictures of them. Before discussing the problems raised by these pictures, it will first be convenient to enumerate them. The following list, in chronological order, includes all that are known to me :—

(I) Predynastic, from Koptos (modern *Kuft*). Engraved upon the back of a colossal statue of the phallic god Min is a stag's head and two *Pteroceras* shells. The stag's head is represented with four tines on each antler, and from the mouth is a long projecting object, which appears to be a stake on which the head is spitted †. (Fig. 1.)

(II) Predynastic, provenance unknown. Ivory knife-handle formerly in the collection of the late Earl of Carnarvon. On this object is engraved a large series of mammals and birds, amongst the former being two stags ‡. (Figs. 2, 2 a.)

(III) Predynastic, from Abydos (between the modern *El-Arabeh* and *El-Kherbeh*). Engraved slate palette representing a lion hunt. The figures include a number of armed men, three lions, an ostrich, and a large series of mammals, amongst which is a stag §. (Fig. 4.)

(IV) Early Dynastic, from Seyala, Nubia. Gold mace-handle engraved with figures of nine mammals and one bird. The elephant and giraffe on this object, I have already discussed ||. A single stag is figured amongst the mammals ¶. (Fig. 3.)

* R. Lydekker, 'A Geographical History of Mammals', Cambridge, 1896, p. 320 and map.

† W. M. Flinders Petrie, 'Koptos', London, 1896, p. 7, pls. iii, iv.

‡ G. Bénédite, 'Journal of Egyptian Archaeology', vol. v, London, 1918, pp. 159, pls. i, ii.

§ F. Legge, Proc. Soc. of Biblical Archaeology, vol. xxxiii, London, 1909, p. 305, pl. xlv.

|| W. R. Dawson, Ann. & Mag. Nat. Hist. ser. 9, vol. xvi. 1925, pp. 655-659; *ibid.*, vol. xix, 1927, pp. 478-485, pl. xv.

¶ C. M. Firth, "Archaeological Survey of Nubia", Bulletin vii, Cairo, 1910, p. 13, fig. 3; *ibid.*, Report for 1910-11, Cairo, 1927, pp. 205-207, pl. xviii.

(V) Fourth or Fifth Dynasty, from Meidûm. Wall-painting in the tomb of Atet. A stag, coloured uniformly reddish brown, is led by a hind who grasps the base of an antler. The head has been damaged, but sufficient remains to show its form and the antlers *. (Fig. 6.)

(VI) Fifth Dynasty, from Abusir. Bas-relief of a hunting-scene on the wall of a chamber in the funerary chapel of King Sahure. The deer is trans-fixed by two arrows †. (Fig. 7.)

(VII) Fifth Dynasty, from Gizeh. Bas-relief on the wall of the tomb of Senedjemib ‡. (Fig. 8.)

(VIII) Fifth Dynasty, from Sakkara. Bas-relief in a chamber in the tomb of Ti. Amongst the farm-animals is a single stag. The animal seems difficult to manage: one hind drags it from in front, grasping the stag's head with one hand and an antler with the other; a second hind pushes the animal by the rump. The inscription above reads, 'bringing the stag (*hnn*)' §. (Fig. 5, the arms of the first hind are shown in the drawing.)

(IX) Sixth Dynasty, from Sakkara. Bas-relief in a chamber in the tomb of Kegemni (Gemni-Kai). The animal is being led with other species of *Ungulata*, but in the drawing it is impossibly small, the tips of the antlers barely reaching to the level of the knees of the man that leads it ||. (Fig. 11.)

(X) Twelfth Dynasty, from Meir, Upper Egypt. Bas-relief on the wall in the tomb-chapel of Ukh-hotp, son of Senbi. The stag appears in a hunting scene; it has been wounded and sinks upon its haunches ¶. (Fig. 12.)

(XI) Twelfth Dynasty, from Sheikh Abd el-Gourneh (Thebes). Coloured bas-relief in Tomb No. 60, that of Antefoker. The two animals, in a hunting-scene, are coloured brown, with light bellies **. (Fig 9, outlines restored.)

(XII) Twelfth Dynasty, from Beni Hasan, Tomb 15. Two stags in a long row of animals in a hunting-scene. The Egyptian name of the deer (*hnn*), is written above them ††. (Fig. 10.)

(XIII) Same date and locality, Tomb 17. Similar scene; a single deer without antlers, labelled *hnn* ‡‡. (Figs. 10 a.)

(XIV) Same date and locality, Tomb 33. Similar scene. Amongst a group of small antelopes (all horned) is a hornless animal, probably a female deer, but no name is written above it §§. (Fig. 10 b.)

* W. M. Flinders Petrie, 'Medum,' London, 1892, pl. xxvii.

† L. Borchardt, 'Das Grabdenkmal des Königs Sahure', Leipzig, 1910, pl. xvii, text, Bd. ii, p. 168.

‡ R. Lepsius, 'Denkmäler', Ergänzungsband, Bl. 23 c.

§ G. Steindorff, 'Das Grab des Ti', Leipzig, 1913, Bl. cxxviii.

|| F. W. von Bissing, 'Die Mastaba des Gem-ni-kai', Bd. i, Berlin, 1905, p. 35, pl. xxv.

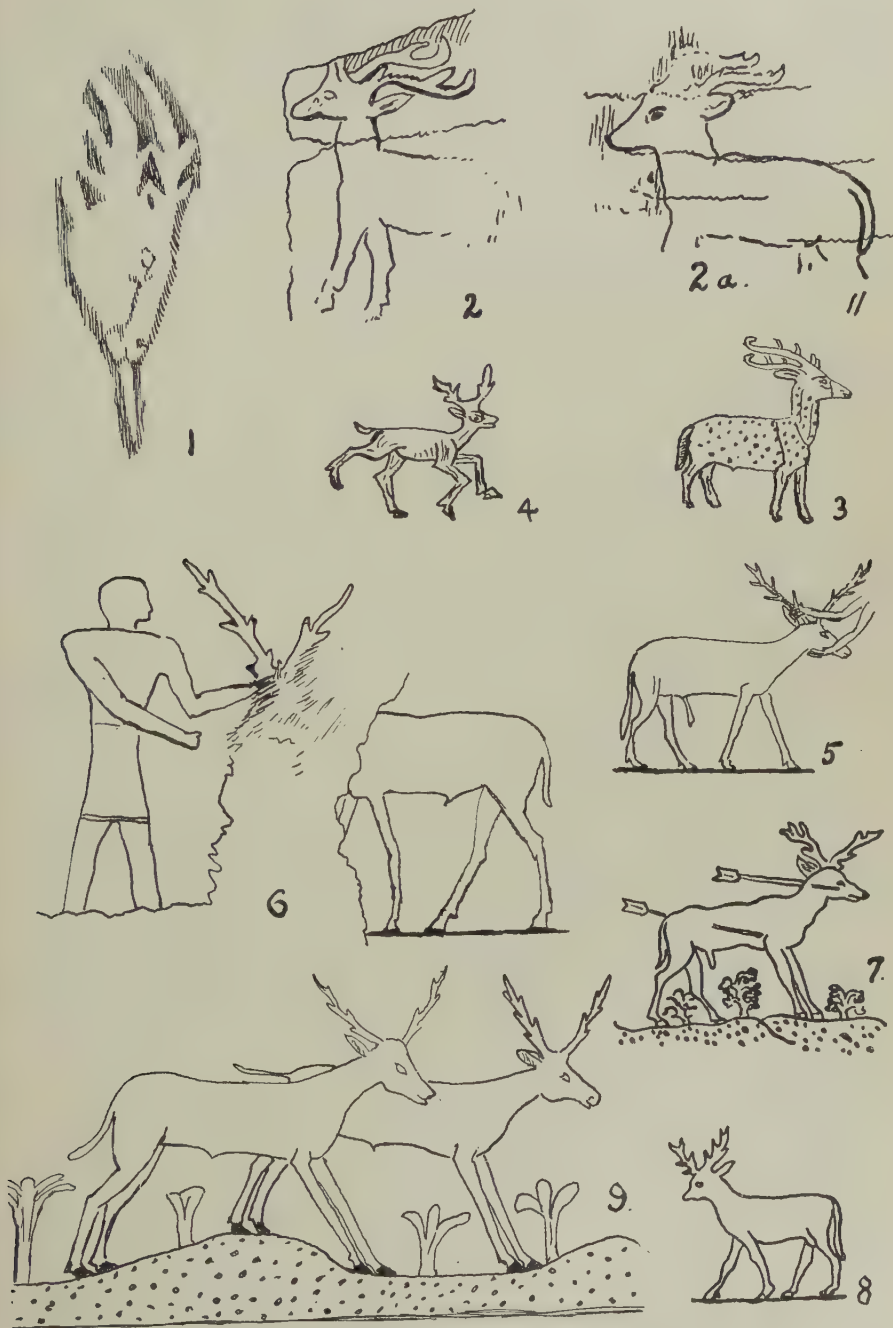
¶ A. M. Blackman, 'The Rock Tombs of Meir', pt. ii, London, 1915, p. 19, pls. viii, xxxiii.

** N. de G. Davies, 'The Tomb of Antefoker', London, 1920, pls. i, v a, vi.

†† P. E. Newberry, 'Beni Hasan', pt. ii, London, 1894, pl. iv.

‡‡ *Ibid.*, pl. xiii.

§§ *Ibid.*, pl. xxxv.



(XV) Twelfth Dynasty, from El Bersheh, Tomb 4. In a fragment of a hunting-scene, a stag is shown falling upon its knees*. (Fig. 15.)

(XVI) Same date and locality, Tomb 5. Fragment bearing the head of a stag with a single antler, the name *hnn* written above it†. (Fig. 11 a.)

(XVII) Eighteenth Dynasty, from Khôkah (Thebes). Tomb No. 39, that of Puyemre (*temp.* Tuthmosis III, c. 1500–1447 B.C.). Wall-painting of two deer (one hornless), browsing on a bush‡. (Fig. 14.)

(XVIII) Eighteenth Dynasty, from Dra Abu'l Neggeh (Thebes). Tomb of Menthirkhopshef (No. 20, same date as last). Fragment from a hunting-scene. Head of stag, coloured light buff, with very conventionalized antlers. This fragment is now in the Cairo Museum §. (Fig. 13.)

The Egyptian name for the deer, as is seen in the tomb of Ti, and in those of Beni Hasan and El Bersheh (above, Nos. VIII, XII, XIII, XVI) is *hnn*, fem. *hnn-t* ||, and this word occurs but rarely in the texts. 'One stag' is mentioned in an inscription of the 38th year of the Pharaoh Tuthmosis III in a list of objects brought from Syria ¶, and in the medical papyri there are preparations made from the antlers of the stag in various prescriptions **. I have dealt with these in a study of the history of hartshorn as a drug ††. The word *hnn* is very rare, however, and I know of no other occurrences of it than those mentioned above, the latest of which dates from the Nineteenth Dynasty. After the Eighteenth Dynasty no pictures of deer have been found, and after the Nineteenth the word *hnn* seems to have dropped out of the language. In such later texts as mention deer, Greek or Semitic words are used. This aspect of the question has been discussed fully by the late M. Georges Bénédite and need not detain us here ‡‡.

The main problem that arises is : Does the presence of the pictures of the deer in ancient Egypt prove that in the period covered by those pictures the animal was a part of the fauna of Egypt ? Secondly and alternatively, do these pictures indicate that deer were introduced by man into the country ?

Whichever of these two alternatives may prove to be correct, there can be no doubt that deer were rare animals, unfamiliar to the Egyptian artists. Animals that were indigenous or domesticated, and therefore well known and

* P. E. Newberry, 'El Bersheh', pt. ii, London, 1895, pl. xi.

† *Ibid.*, pl. xvi.

‡ N. de G. Davies, 'The Tomb of Puyemre', New York, 1924, vol. ii, p. 46, pl. vii.

§ N. de G. Davies, 'Five Theban Tombs', London, 1913, p. 8, pls. i, xii.

|| The word occurs also in one of the tombs of Deir el-Gebrawi, but the artist has made a mistake, for the animal so designated is an ibex.

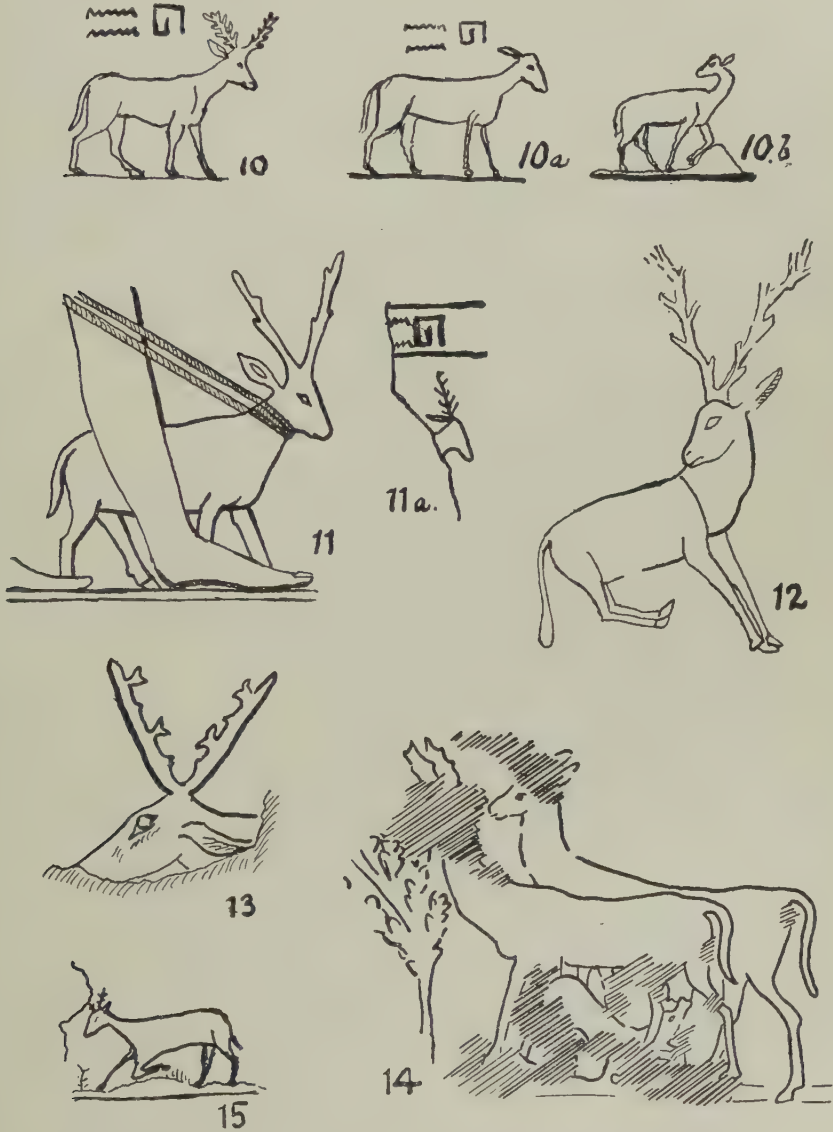
¶ Kurt Sethe, 'Urkunden der 18 Dynastie', Leipzig, 1906, p. 718.

** "Ebers Papyrus", 48. 15–17 ; Berlin Medical Pap. 6. 9–10 ; 11. 11–12 ; "Louvre Ostrakon 3255", lines 1–2.

†† W. R. Dawson, "Studies in Ancient Materia Medica", § IV. 'American Druggist', New York, March 1926.

‡‡ G. Bénédite, *Journ. of Eg. Archaeology*, vol. v, 1918, pp. 12–13.

frequently seen, are sculptured or drawn with great exactness and fidelity to nature. Even from carvings of the early Predynastic period (long anterior to the beginning of the First Dynasty, which by general agreement is now



dated about 3400 B.C.) many species of mammals and birds can be identified with confidence, and, from the time of the Pyramid Age (Dynasties IV–VI) onwards, animals are usually depicted with a degree of accuracy that would

often almost satisfy the needs of modern science. Now all the early pictures of deer, whilst they represent the general outline of the head, body, and limbs correctly, err considerably in the details of the antlers. We must therefore use the greatest caution in attempting to identify species from such materials. In the case of the various kinds of antelope—oryx, addax, dorcas, etc.—the specific characters are accurately enough drawn to enable us to name the species without any doubt, because these were familiar animals, and many of them were reared for food or for hunting and are very common in the pictures of farming scenes.

It may be taken for granted that the deer of Egypt, whether naturally present or introduced, were derived from the species whose habitats are nearest to that country. We have therefore to choose between two species that have been suggested, one occupying North Africa and the other Western Asia. The first of these is a local race of the typical Red Deer, and is described by Lydekker as follows :—

‘ *Cervus elaphus barbarus*.

‘ Typical locality North Africa ; now found in certain parts of Algeria, Tunisia and Senegambia, but apparently very scarce.

‘ Size considerably smaller than in the typical race ; bez-tine of antlers generally wanting ; general colour dark brown, with a greyish-brown dorsal stripe and irregular whitish spots on flanks and in some cases on back ; rump-patch much lighter than back, without dark anterior border, and including tail. Maximum antler-length 38½ inches’ *.

The other species, to which Egyptologists generally refer the Egyptian drawings, is that first described by Sir Victor Brooke, the Persian Fallow Deer †. Lydekker’s description of this species is as follows :—

‘ *Dama mesopotamica*.

‘ Larger than *D. dama* ; the colour much brighter (as bright as the Indian chital), with a row of elongated whitish spots on each side of the dark median line of the back in the former coalescing into a continuous band, and the black on the upper surface of the tail narrower and confined to the root ; antlers of a totally different type, being somewhat expanded at the origin of the bez-tine, which is large and situated close to the very short brow-tine, but at the summit only somewhat flattened, and breaking up at the crown and summit of the hind border into four, five or more snags.

‘ Typical locality Luristan Province of Persia’ ‡.

To these two species must be added a third, the Common Fallow Deer (*D. dama*), which long survived in the Lebanon district §.

* R. Lydekker, ‘ Catalogue of the Ungulate Mammalia in the British Museum ’, vol. iv, 1915, p. 120.

† Proc. Zool. Soc., 1875, p. 265 ; 1876, p. 298.

‡ R. Lydekker, *op. cit.*, p. 45 ; cf. his ‘ Deer of all Lands ’, London, 1898, p. 132.

§ H. B. Tristram, ‘ Natural History of the Bible ’, 2nd ed. London, 1868, p. 85.

Dr. Max Hilzheimer, discussing the question of deer in Egypt*, came to the conclusion that the Egyptian pictures of deer must be referred to the species *D. mesopotamica*, despite the fact that its range is limited to Persia. He explains its presence in Egypt by the hypothesis that it migrated thither in what he calls 'the pluvial epoch', basing the theory on cervine remains of the Pleistocene in Palestine. Most other writers seem to have adopted Hilzheimer's hypothesis that *D. mesopotamica* or *D. dama* was once actually wild in Egypt. In more recent years, Bénédite, whilst accepting this theory, went still further. He identified the two deer on the Carnarvon Ivory (figs. 2, 2a) as belonging to two species, one being *C. e. barbarus* and the other *D. mesopotamica*, and postulated that the range of the African species formerly extended to Egypt, and that both were natives of the Nile Valley at the time when the Carnarvon Ivory was made. He admits that they were rare, and had become extinct by the time of the Nineteenth Dynasty. These claims, it seems to me, are over-bold, being based, as they are, on the evidence of a single artefact and the disappearance of the word *hnn* from the language of Egypt †.

The African species is strictly limited in range, but that it is not a recent introduction from Europe is proved by the discovery of fossil cervine remains from Algeria ‡. The Algerian race has evidently inhabited its present region since the land-bridge with Europe existed in Tertiary times. There have been no osseous remains of deer, either recent or fossil, discovered in so well explored a region as the Nile Valley §, and, as the entire family of Cervidae is absent from the Ethiopian Region of Africa, it seems to be in the highest degree improbable that any species has ever inhabited the African continent other than *C. e. barbarus*. It is known that in very early times the Egyptians had relations both with the South and with Western Asia, and the racial admixtures are to be detected in the early human remains of the Nile Valley ||. Amongst the animals depicted on the archaic objects mentioned above (I-IV) are typical African species, such as the elephant (quite undoubtedly the African species), giraffe, and ostrich, and, as a deer of Asiatic origin is included amongst them, it would seem that these artefacts are the work of Egyptians who had inter-

* In L. Borchardt, 'Das Grabdenkmal des Königs Sahure', Leipzig, 1910, text, p. 168.

† G. Bénédite, *op. cit. supra*.

‡ R. Lydekker, *Proc. Zool. Soc.* 1890, p. 602. See also Bénédite, *op. cit.*, p. 13, n. 2.

§ An exception to this statement must be made in the case of a single small fragment of an antler found at Kau-el-Kebir in 1922-3. This was at first believed to be fossil, as it was found with a deposit of fossil hippopotamus bones (not *in situ*, but collected and buried in historic times). Prof. D. M. S. Watson, who has examined these bones, tells me (in a letter dated 12 May, 1931) that the cervine bone is 'a small fragment of an antler of the Persian variety of red deer. It was quite certainly recent at the time it was buried, that is, 18th or 19th dynasty, and formed no part of the fossil material from that locality.' The fragment may have been part of a knife-handle or other artefact, as was clearly imported from Asia, with which Egypt was in constant intercourse at the period.

|| This question is fully discussed in G. Elliot Smith, 'The Ancient Egyptians', 2nd ed., London, 1923.

course with the peoples of both regions. There is no evidence whatever of cultural contact with North-west Africa (the region of *C. e. barbarus*), and Bénédite has postulated a vast extension of its range in order to account for the single picture of the animal that he so identifies. He identifies the deer of the Carnarvon Ivory (fig. 2) with *C. e. barbarus* on the strength of the two projections seen rising from the brow of the animal. Speaking of the other known representations of deer in Egypt, Bénédite says: 'It is true that, compared together, they do not display complete identity, but they possess as a common character horns of vague form, bristling with short and irregular tines, and further no brow-tine starting boldly from the bosset or crown with a pronounced curve forwards and upwards. Now it is just this that is the most noticeable character of the horns of our deer. Their parallel direction, of which the ten representations mentioned above* afford but two examples, is here justified by the necessity of making the two brow-tines project in front of the brow . . . Further, the beam is harmoniously curved back and only two tines branch off from it—the bez-tine and the trez-tine. A hunter would recognize in it a red-deer with its third horns, that is a four-year-old' †.

If the above-mentioned characters justify the identification of the deer of the Carnarvon Ivory with *C. e. barbarus*, the Nubian specimen (fig. 3) is equally entitled to the same designation ‡. It may be objected that the latter, being spotted, must represent a Fallow Deer; but no reliance can be placed upon the spots, because the African Elephant and lion on the same monument are represented as spotted §. It seems to me much more probable that the representation of parallel shafts is influenced by those of the more familiar antelopes, and the horns arising from the animal's forehead by the frontal horns of the giraffe. The details of the deer being quite unfamiliar to the ancient artist, he composed the horns on the model of those of other animals with which he was fully acquainted. There is still a further possibility, however, that is consistent with Mr. Bénédite's premises. If, according to him, the Mesopotamian Fallow Deer migrated to Egypt and inhabited the Nile Valley, there would seem to be no reason why one of the Asiatic species of the Cervine group (a race of *C. elaphus* from Persia, for instance) should not have done the same. If the deer which he so confidently identifies with *C. e. barbarus* really belongs to the Cervine rather than to the Damine group of the family, he could bring both his species from Asia without necessitating the vast easterly extension of the range of *C. e. barbarus* that he postulates ||. Actually, however, there is not a particle of osteological evidence, either recent or fossil, to justify either hypothesis.

* Bénédite's list of ten examples is incomplete. He gives actually only nine cases, two of his references being duplicates.

† *Op. cit.*, p. 14.

‡ Bénédite calls this an Axis deer!

§ C. M. Firth, 'Archaeological Survey of Nubia', Report for 1910–11, Cairo, 1927, pl. xviii.

|| On the Assyrian monuments, both Cervine and Damine deer are represented. See W. Houghton, *Trans. Soc. Biblical Archaeology*, vol. v. 1877, pp. 342–5, pl. iv.

In the pictures of deer here reproduced, in nearly all cases the antlers are obviously conventionalized, but some of them are more definitely palmate than the rest (e.g. figs. 4, 7, 8). All of them might be conventionalized renderings of the antlers of *D. mesopotamica* (except, perhaps, figs. 13 & 14), which do not terminate in the broad palmation revealed by those of *D. dama*. The stag shown in fig. 14, with its broadly palmated antlers, might possibly be based upon *D. dama* from Palestine.

In conclusion, it must be admitted that there is no positive evidence in favour of, and much presumptive evidence against, the hypothesis that deer were ever wild or introduced into Egypt, either in ancient or in historic times. But I think the pictures of them on Egyptian monuments can be accounted for in another way. I suggest that on a few rare occasions captive living animals may have been brought from western Asia, and on the strength of this rare occurrence the artists sought to give the impression that deer took their places with the other animals of the farm and hunting-preserves, in the same way that the giraffe and other non-indigenous animals were sometimes so represented. If some of the Egyptian drawings were made from living models, it is quite clear that many were not, and were drawn, by artists who had never seen the originals, from sketches brought by their far-travelled countrymen who had observed the animals in their native haunts. That the drawings often had such an origin is clearly shown by the pictures of a fully-tusked elephant standing no higher than a man's waist *, and a stag with full-grown antlers whose stature is less than that of a man's tibia. (Fig. 11.)

* W. R. Dawson, *Ann. & Mag. Nat. Hist.*, ser. 9, vol. xvi, 1925, p. 658, fig. 4.

Results of the Cambridge Expedition to British Guiana, 1933. The fresh waters of the rain-forest areas of British Guiana. By G. S. CARTER, M.A., Ph.D., F.L.S.

(Plates 1-3 and 3 Text-figures)

[Read 26 April 1934]

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INTRODUCTION.

In the last few years several biologists have worked upon the oecology of tropical fresh waters. It is not surprising that the greater number of these investigations are concerned with the lakes of tropical countries for, up to the present, much more oecological work in temperate countries has been given to the lakes than to any other fresh-water environment. Jenkin (1932), Worthington (1930, 1932), Beadle (1932), Thienemann (1930), and Ruttner (1931) have all published accounts of tropical lakes. We are now able to form some conception of the conditions which are characteristic of that environment, and to compare them with the conditions in temperate lakes.

We still know very little of other types of tropical fresh waters. The streams have received some attention. Pruthi (1933) has published an account of a stream in the Salt Range of the Punjab, and Allee and Torvik (1927) have described a stream in the rain forest of Panama. Van Oye (1922, 1926) gave the results of his investigations of river water in Java and at Ruki on the Congo. A few other similar pieces of oecological work may be found in the literature.

Among these investigations we have some accounts of fresh waters in the forest countries of the tropics, but it cannot be questioned that our knowledge of most types of forest waters is fragmentary.

In the present paper an account is given of the chemical and physical characteristics of the fresh waters of some rain-forest areas in British Guiana. The work was done during a visit to the Colony in 1933 *. A party of four biologists took part in the expedition and co-operated in carrying out the general object for which the expedition was organised. This object was to make a survey—necessarily rapid, since only four and a half months were available for work in the field—of the oecology of the fresh waters of a tropical forest country, and, so far as the time allowed, of the adaptations of the fauna to these conditions. British Guiana was chosen as the country to be visited on account of the suitability of its climate, its large areas of forest, and its accessibility from Europe.

The observations here reported were undertaken as a part of this plan.

We chose the oecology of the waters of a tropical forest country as the subject of our investigation partly because so little work had previously been done on waters of this type, and partly on account of the special interest of these waters. It is agreed among palaeontologists that the environment of the shallow fresh waters, and, perhaps, especially of such waters exposed to warm and humid climates, has been of great importance in the evolution of animals. It was hoped that a study of the conditions which occur in such waters to-day might throw some light on the causes which have produced in similar waters the evolutionary changes of the past.

* We are greatly indebted to the several bodies who made the expedition possible by providing grants towards its expenses and especially to the Trustees of the Percy Sladen Memorial Fund, the Royal Society, the Trustees of the British Museum, and the British Association for the Advancement of Science.

I should like here also to express our great debt to the many residents in British Guiana who made it possible for the work of the expedition to be carried out. In particular, mention should be made of our debt to His Excellency the Governor, Sir Edward Denham, K.C.M.G., K.B.E., for his invaluable support and advice, to the Hon. B. R. Wood of the Forestry Service for his hospitality at the Mazaruni Station and for help of every kind while we were staying there, and to Mr. F. B. Henderson of the Demerara Bauxite Coy. for similar help and hospitality at Mackenzie on the Demerara.

In the preparation of the paper, I have been greatly helped by Mr. J. T. Saunders of Christ's College, Cambridge.

In addition to these, there were other reasons which made it desirable to investigate waters of this type. Previous work on shallow swamps in the Paraguayan Chaco (Carter and Beadle, 1930) had shown that the conditions in shallow and stagnant tropical waters may be very different from those in apparently similar temperate waters. It was hoped to compare the results previously obtained with observations on similar waters in the very different climate of the Guiana forests, and thus to determine how far the conditions observed in the Paraguayan swamps are the results of the peculiar climate of that country, and how far they may be general to tropical waters of these types. Also, there has been great improvement in some of the chemical methods of water analysis since the observations were made in the Paraguayan Chaco, notably in those for the estimation of dissolved oxygen and free carbon dioxide. It was desired to confirm the conclusions of the earlier work by the use of these, newer, methods.

GEOGRAPHY.

The colony of British Guiana lies between lats. 8° and 1° N. and longs. 57° and 61° W. It forms a part of the northern coastlands of South America, which are here between three and four hundred miles broad. It is separated from the countries to the east and west of it by no natural features of geographical significance. To the south it extends to the watershed, which, at heights varying up to 3000 ft., separates the coastlands from the drainage area of the Amazon. On the coast there is a flat alluvial plain a few miles wide, but over the rest of the colony the land slopes upwards, more or less evenly, to the watershed. The evenness of the slope is, however, broken in many places by ranges of hills which rise several hundred feet above the general level of the surface. Throughout the interior the subsoil is composed of igneous rock or, especially in the higher districts, of sandstone. The subsoil everywhere contains very little inorganic salt and, above all, very little lime.

For almost the whole of the year, the colony lies in the path of the northeasterly trade winds. These winds, and the large amount of moisture which they bring from the Atlantic, are responsible not only for the heavy rainfall, which is characteristic of the whole colony, but also for the distribution of the rain in frequent, relatively slight storms or showers. In Guiana rain falls on the average on about 200 days in the year. It is the frequency of the rain, rather than its total amount, which determines the type of the climate and produces the conditions necessary for the development of the rain forest, with which the whole of the colony, with the exceptions of the alluvial plain on the coast and of some areas of upland savannah in the south, is covered.

That the rivers should be large and numerous is also a natural result of the high rainfall—and of the low evaporation which is typical of a forest area. The colony is drained by a number of rivers, most of which lie more or less parallel to each other, flowing in a northerly direction from the southern watershed to the sea. In the upper parts of these rivers rapids and small falls are

frequent, and the current is usually swift, but these obstructions cease at distances from the coast which vary between 50 and 100 miles. Below the falls the rivers are tidal and the current is less rapid, varying with the tide.

The largest of the river systems is the most western, which contains three rivers—the Essequibo, the Mazaruni, and the Cuyuni. The two last of these rivers drain the most western part of the colony and flow rather to the north-east than to the north, for in this region the watershed turns to the north, separating the basins of these rivers from that of the Orinoco, which drains the coast lands to the west of the Colony. It was in the area of these three rivers that most of the observations to be discussed in this paper were made. At the beginning of our stay in Guiana, we spent two months, May and June, at the Mazaruni Forestry Station ($6^{\circ} 24' \text{ N.}$, $58^{\circ} 40' \text{ W.}$). This station is situated on the north bank of the Mazaruni River about three miles to the west of its junction with the Essequibo and two miles to the east of the place where it is joined by the Cuyuni. The river at the station is therefore the combined streams of the Mazaruni and the Cuyuni. During our stay at the station the waters of the river and of the streams and swamps in the neighbouring forests were investigated.

The first falls on all three rivers are a few miles above the Mazaruni station. We wished to form some estimate of the effects produced by the disturbance of the tide and also to investigate the forest and river waters in an area farther from settlement. For these reasons, in July, we made camps on the Cuyuni 10–15 miles above the station, where the river is not tidal. In these camps the analyses, both of the river waters and of the waters of the forest streams and swamps, were continued.

Finally, in August, a visit was made to Mackenzie ($5^{\circ} 58' \text{ N.}$, $58^{\circ} 17' \text{ W.}$) on the Demerara, the river which drains the second of the river basins of Guiana as one passes across the colony from the west. The object of this visit was to compare the waters of the Demerara and of some of its contributory streams with similar waters in the Essequibo system.

VARIETIES OF THE RAIN FOREST.

The forests of Guiana are by no means uniform. The varieties of the forest which are to be found in the Essequibo region have been described by Davis and Richards (1933), and reference must be made to their paper for a fuller description than can be given here. In the regions in which the observations of this paper were made three of the four types of undisturbed forest which Davis and Richards recognise are to be found. These forests have been shortly described in a previous paper (Carter, 1934). Here the descriptions will be very shortly summarised.

The three varieties of forest are :—

1. *Mora forest*, typical of the low and damp ground near the river. In the Cuyuni region this forest is very dark and the undergrowth in it is thin. *Mora* (*Mora excelsa* Bth.) is strongly dominant,

2. *Mixed forest*, usually found on higher and drier ground than the Mora forest ; frequently less dark than the Mora forest and with thicker undergrowth. Mora occurs among many other trees.

3. *Wallaba forest*, found on the highest and driest ground ; less dark, and thicker, than either of the previous types. Wallaba (*Eperua* spp.) is dominant.

In addition to these varieties of forest, swamp forest of more than one type occurs in occasional places near the streams, and in hollows where water accumulates. Swamp forest is distinguished by the presence of a large proportion of palms among its trees (especially the Manicole palm, *Euterpe oleracea* Mart.), and, where the shade is not too dark, by a considerable amount of aquatic vegetation above the surface of the water. It varies in the amount of the vegetation at ground-level and, to some extent, in the characters of the trees.

Swamp forest is usually less dark than the drier types of forest, but this is not always so.

Wherever the primary forest has been cut or otherwise destroyed, secondary forest grows up to take its place. This has occurred over most of the country within three or four miles of the Mazaruni Station. In this area a fire destroyed the forest about five years before our visit. Here, the secondary growth now consists of low forest 30–40 ft. high with a variable proportion of tall trees which have survived the fire. In places these trees are thinly scattered, but elsewhere they are sufficiently numerous to form a canopy. Secondary forest is always lighter and thicker at ground level than undisturbed forest.

CLIMATE.

An account of the climate of the region around the Mazaruni Station has been given by Davis and Richards (1933). Here only the few facts which are necessary for the following discussion will be mentioned. These facts have mostly been extracted from the paper by Davis and Richards and a report by Reed (1928). Some data of the climate within the forest at ground level will also be given.

The climate of Guiana shows in a marked degree the absence of large seasonal variations which is characteristic of equatorial climates. The yearly range of the mean temperature is less than 2° C., and is much less than the mean diurnal range of temperature (about 8° C., max. 30° C., min. 22° C. There is little seasonal variation in the direction of the prevailing winds and in the general type of the weather. Seasonal variations are not, however, completely absent. They are most marked in the amount of the rainfall and in the factors, such as humidity and sunshine, which are correlated with the rainfall. The average yearly rainfall is very variable in localities which are close to one another. At the Mazaruni Station the average is 103·5 ins. There are two rainy seasons, in December and from the latter part of May to the end of July. The monthly mean rainfall varies from 13·8 ins. in June and 11·3 ins. in December to 5·2 ins. in February, the least rainy month. These differences are con-

siderable, although by no means so great as in some other areas of tropical rain forest (e.g. Panama, Kenoyer, 1929). Marked seasonal changes in the dampness of the forest and in the height of the rivers result from these variations in the rainfall, and are enhanced by the correlated variations in the amount of sunshine and in the humidity. The yearly average of the daily sunshine is 5.6 hrs., 45–50 per cent. of the sky being covered with cloud. The sunshine varies from an average of 4.8 hrs. in June to 6.6 hrs. in September. The average relative humidity is 93.7 per cent at 7.0 a.m. and 78.8 per cent. at 1.0 p.m. (Mazaruni Station, Davis and Richards, 1933). The mean relative humidity is 85 per cent., rising to 87 per cent. in June and July and falling to 81 per cent. in April.

Although there are two moderately definite rainy seasons, the rain at all times of the year is irregular. Rain falls on more than half the days of the year, but it is chiefly the somewhat infrequent heavy falls of rain which determine the amount of water in the forest and the height of the rivers. These heavy rainstorms are more frequent in the rainy seasons, and the forest is wetter then and the rivers higher. But this is by no means always true throughout the rainy season. After one storm of rain the forest may dry to a large extent before the next storm. Similarly, the height of the rivers varies irregularly and at short intervals, both in the rainy seasons and at other times.

It was, for us, a fortunate circumstance that the seasonal variations of the climate of Guiana are so largely confined to variations in the rainfall. Since we were only able to spend four and a half months in the colony, we could not have observed the effects of seasonal changes on the condition of the waters, if these changes had occurred at intervals of six months, as they do in temperate countries. We were, however, able to work through one rainy season (May, June, and July) and to observe the condition of the water in the dry weather both before and after this wet period. We were therefore able to observe the effects of the seasonal variation in rainfall.

Most of the data which have been given here are derived from the records of the meteorological station at the Mazaruni Station, where the instruments are situated in a large open clearing. It is well known that the climate within a tropical forest is much more constant than that in a neighbouring clearing, and that the constancy of the forest climate increases with the depth below the canopy at which the observations are taken, being greatest at the ground level (McClean, 1919; Allee, 1926). To provide some basis for estimation of the differences between the true forest climate in the districts in which we were working and the general climate of the country, observations were taken during July in the forest near the camps on the banks of the Cuyuni. It must, however, be remembered that these observations were taken only during the rainy season, and that their period, 23 days, was very short.

The instruments were fastened to the trunk of a tree in Mora forest at five feet from the ground and at least 100 yards within the forest. Since there is no appreciable wind within the forest, it was thought unnecessary to protect the

instruments by more than a cover to shield them from the rain. A thermograph, maximum and minimum thermometers, hygrometers, and evaporimeters were set up.

The thermograph showed a diurnal range of temperature varying between 3° and 5°C . (text-fig. 1). Some observations which were taken for ten days at 8.0 a.m. and 2.0 p.m. within 6 ins. of the ground and at a height of 7 ft. showed that the diurnal temperature range on the ground is less than that at a few feet above it. The average difference between the morning and afternoon observations at 6 ins. was $3^{\circ}\cdot 2\text{C}$. At 7 ft. it was $3^{\circ}\cdot 6\text{C}$. The lower of these figures is approximately equal to the range observed by Allee (1926) at the

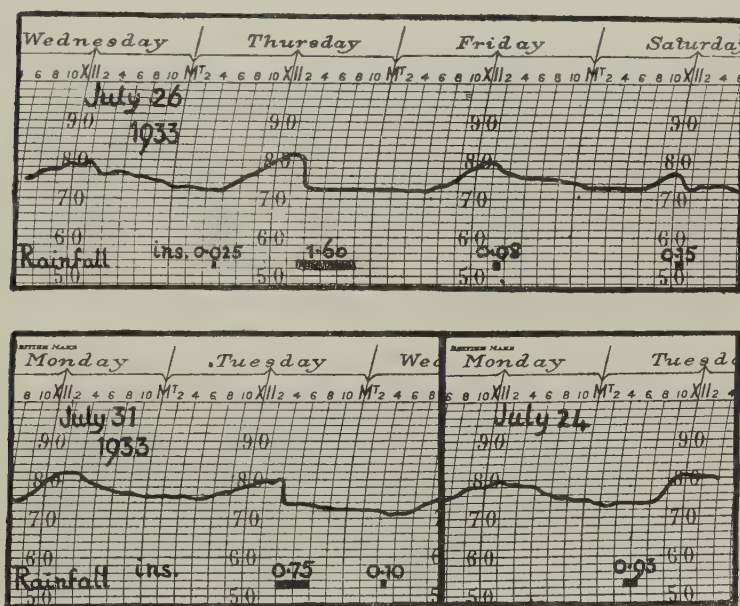


FIG. 1.

ground level in the forests of Panama ($2^{\circ}\cdot 9\text{C}$). In the morning the air at 7 ft. was $0^{\circ}\cdot 1\text{C}$. cooler than that at 6 ins. In the afternoon it was $0^{\circ}\cdot 3\text{C}$. warmer.

A noticeable feature of the forest climate was the large fall in temperature which resulted from rain during the day. This is shown in text-fig. 1 (July 27, 28, 29, Aug. 1), where it is seen that a rainstorm may cause an almost immediate fall of the temperature, which is nearly as large as the diurnal range. Rain at night did not produce any similar fall of temperature (July 25).

The average relative humidity at 5 ft. during the period of the observations was 96.6 per cent. at 8.0 a.m., 91.3 per cent. at 2.0 p.m. and 96.5 per cent.

at 8.0 p.m. Thus, the relative humidity in the forest is considerably greater than that in a clearing in the middle of the day, but not very different from it at night. In humidity as in temperature there is a recognisable gradient in the first few feet above the ground. The averages of the observations for ten days gave the following figures :—

	6 ins. per cent.	3 ft. per cent.	7 ft. per cent.
Relative humidity ...			
8.0 a.m.	97.1	96.8	96.5
2.0 p.m.	93.4	92.4	89.3
8.0 p.m.	97.3	97.1	97.1

These figures show that the gradient in relative humidity is greatest in the daytime, as is that in temperature.

Considerable differences in humidity and temperature were found between different types of forest. Comparison over 8 days between positions in Mixed and Mora forests, within two hundred yards of each other and both near the river, gave the following results :—

	8.0 a.m.	2.0 p.m.	8.0 p.m.
Temperature	° C.	° C.	° C.
Mixed forest	24.5	26.9	23.4
Mora forest	24.3	26.3	23.3

	per cent.	per cent.	per cent.
Relative humidity ...			
Mixed forest	97.1	84.9	97.2
Mora forest	98.1	90.8	97.4

These results were all taken at a height of 5 ft. Here again the difference is greatest in the middle of the day. The results agree with those of Davis and Richards (1933) in showing the Mora forest to be the most humid.

Evaporation was measured by the fall of a water surface exposed to the air. In the forest at a height of 5 ft. the average daily fall for 24 days in July was found to be 0.5 mm. Another series of observations were made between May 12 and May 30 in an open grass swamp near the Mazaruni Station. Here the average daily evaporation from the surface of an open pool exposed to the sun was found to be 2.0 mm. and that on the surface of a shaded pool 1.0 mm. The shaded pool was covered with vegetation consisting of thick growth of grasses and ferns to a height of 5 ft. above the water.

The figure of 2.0 mm. a day gives a maximum for the evaporation from a water surface at ground level in the climate of this region and at the time at which the observations were made. The evaporation would probably be somewhat greater in the dry season. However, by far the greater area of the country is covered with forest and, for the country as a whole, the evaporation at ground level must be much nearer the figure found for the evaporation in the forest, 0.5 mm. a day.

It has been stated that the rainfall is about 100 ins. a year, or 7 mm. a day. The loss of water from ground covered with vegetation may be several times

that from uncovered ground, but, in view of the high humidity of the climate of Guiana, the loss from the trees is not likely to be greater, and may be much less, than the 3 mm. a day over the area of the ground which is given as the average daily loss from an English wood in the summer. It is thus clear that the true evaporation quotient of the forest, i.e. the proportion between the water lost by evaporation and that brought into the forest as rain, is very considerably less than unity and is probably not greater than 0.5. It may be considerably less than this figure. This conclusion is borne out by the great quantity of water which flows from the forest in the rivers. The forest is therefore continually washed by a current of water which flows from the higher to the lower ground.

ANALYTICAL METHODS.

I am indebted for the analyses of electrical conductivity and mineral content, which are given in Appendix I, to the Government Chemist, Sir R. Robertson, K.B.E., F.R.S., in whose laboratory in London they were carried out. Quart samples of the various waters were brought back from Guiana for this purpose. These analyses are only intended to define the general character of the mineral content of the waters investigated. It was not possible to bring back a sufficient number of samples for the examination of the seasonal variations in mineral content. To some extent the determinations of chloride content, which were carried out in Guiana, supply data from which these estimations may be derived. In waters taken at different times from the same source the mineral content is not likely to vary greatly in the proportions of the different salts present. It may therefore be taken to be roughly proportional to the chloride content.

All the other analyses were carried out in Guiana as soon as possible after the samples were collected. At the Mazaruni Station we were allowed to fit up a very satisfactory laboratory in some rooms of the disused hospital of the settlement. In the camps on the Cuyuni the work had to be done in less convenient circumstances under the shelter of a tarpaulin. However, it was found possible to carry out all the analyses in the camps except that of organic nitrogen by Kjeldahl's method.

Samples from the deeper water were collected by means of a self-closing water bottle. Those for gas analysis were collected in Winkler bottles of about 125 c.c. capacity. In filling these bottles the usual precautions were taken against alteration of the gas content by contact with the air. The method adopted was to fill the sample bottle within a larger bottle, so that only the last part of the water to enter was collected.

The chemicals were taken out from England, both in bulk and in weighed quantities, in sealed glass tubes. A wire balance (Trevan, 1926), which was accurate to 0.1 mg. for small quantities, was included in the equipment and was occasionally very useful.

A supply of distilled water was obtained from a copper still. This supply was,

however, not sufficient for all purposes and clean rain water was used for diluting the samples, in the analyses of organic content, where this was necessary. The rain water was always shown by analysis to be free from organic content before it was used. At the Mazaruni Station no difficulty was found in obtaining a supply of clean rain water, but in the camps this was not so easy. It was difficult to avoid contamination of the water by falling leaves. In the end a method was used in which the water was collected on a sheet of muslin stretched horizontally and dipping in the centre into the mouth of a bottle. When this was set up in the middle of a clearing, the results were satisfactory.

The following characters of the waters were recorded :—

1. Temperature.
2. Turbidity.
3. Colour.
4. H-ion concentration.
5. Content of dissolved oxygen.
6. " free carbon dioxide.
7. " free acid other than carbon dioxide.
8. " bicarbonates (alkali reserve).
9. " phosphates.
10. " silicates.
11. " free ammonia.
12. " nitrate nitrogen.
13. " nitrite nitrogen.
14. " organic nitrogen.
15. " chlorides.
16. Penetration of light.

1. *Temperature* was measured in the deeper waters by a reversing thermometer. In the swamps and pools maximum and minimum thermometers were also used.

2. *Turbidity* was measured by a turbidity rod (Amer. Publ. Health Assn., 1925, pp. 5, 6).

3. *Colour*. The waters investigated differed very little in tint, being almost all golden or brownish yellow. But they differed greatly in the intensity of the colour. This was roughly estimated.

4. The *H-ion concentration* was measured by Sørensen's indicator method. The sulphone-phthalein indicators were used in a comparator.

The indicators were used over the following ranges :—

Phenol Red	pH 7·0-8·0
Brom-thymol blue	6·5-7·0
Brom-cresol purple	5·8-6·5
Chloro-phenol red	5·0-5·8
Brom-cresol green	3·8-5·0

The buffers used were Sorensen's phosphate buffers over the range pH 8.0-5.4 and Walpole's acetic acid-acetate buffers in the more acid range.

The figures for pH are given as the direct readings of the observations and have not been corrected for the salt errors of the various indicators.

5. *Dissolved oxygen* was determined by Alsterburg's modification of the Winkler process (1926). The water is first treated with a bromine solution, by which any organic substances present are oxidised. The later determination of the oxygen content is therefore free from possible errors due to the presence of such substances. The method has been shown by Alsterburg to be effective.

No difficulties were met in using this method in Guiana. The results were occasionally confirmed by extraction of the dissolved oxygen in a van Slyke apparatus, which was taken to Guiana for the physiological work of the expedition. These confirmations were carried out in both well and poorly oxygenated water, and gave agreement within the limits of error of the van Slyke apparatus.

The error in the determination of dissolved oxygen is probably not greater than 0.1 c.c. per litre. The results are given in c.c. per litre and as the percentage saturation deficiency at the temperature of the observations.

6, 7. *Free carbon dioxide and other free acids.* Free carbon dioxide was determined by a method due to Titherly*. Free carbon dioxide is taken to mean free carbonic acid either as H_2CO_3 or as its ions H^+ and HCO_3^- .

Most of the waters investigated contained free acids other than carbon dioxide. In Titherly's method other free acids, if present, would interfere with the results, and would, in fact, be included in the estimations of free carbon dioxide. It was necessary to devise a method by which this difficulty could be avoided. The method finally adopted was to boil the sample to two-thirds of its original volume, in order that the free carbon dioxide might be removed, to determine the free acid in the boiled sample by titration with Na_2CO_3 , and then to adjust the results of the titrations for free carbon dioxide, carried out on another, untreated, sample, accordingly. If any of the other acids were either volatile or destroyed by boiling, it is clear that this method would not give accurate results, for such acids would be included in the estimations given for free carbon dioxide. But (1) there was no evidence of the presence of other volatile acids and (2) it was found that there was no appreciable change in the total acid present in the boiled sample when the boiling was continued from 5/6 to 1/2 of its original volume. If acid was destroyed by the boiling, the destruction would almost certainly have been gradual.

The error in the determination of free carbon dioxide is undoubtedly larger than that in the determinations of dissolved oxygen. It is not claimed that the results are accurate to less than 1 c.c. per litre. The results were confirmed in some instances by van Slyke extractions and the agreement was here,

* This method has not yet been published, and I am indebted to Dr. A. W. Titherly for permission to publish the results obtained.

as in the estimations of dissolved oxygen, as close as could be expected. With the exception of one analysis, which has been rejected, the agreement was within 1 c.c. per litre.

The concentration of free carbon dioxide is given in c.c. per litre. That of other free acids as the normality of Na_2CO_3 required to neutralise them.

8. *Bicarbonate content (alkali reserve)*. This was measured by titration with N/100HCl against methyl orange. The pH of many of the samples was within the range of the indicator. For these samples the alkali reserve is taken to be zero. The results are given as the normality of the acid used.

9. *Phosphate content* was measured by the method of Atkins (1923) modified from that of Denigés (1921). In this determination the strong natural colour of many of the waters introduced difficulties. The colour was not completely removed by any of the usual methods of decolorisation, and some means had to be devised for making the estimations in its presence. The colour was not altered by the addition of the reagents, but the concentration of phosphates was not great enough to allow the method described in a previous paper to be used (Carter and Beadle, 1930). It was found to be possible to get accurate results by the following method:—

Four Nessler tubes were filled to the same height with :

- (1) The standard solution of phosphate, treated with the reagents.
- (2) The untreated sample.
- (3) Distilled water.
- (4) The treated sample.

By placing the tubes above each other in the pairs 1, 2 and 3, 4 and looking along the lengths of the tubes the colours could be matched, the quantity of liquid in tube 1, which contained the standard solution of phosphate, being altered. By this means the density of the natural colour was made the same in both pairs of tubes, and therefore did not interfere with the matching of the colour. The same method was used in the estimations of silicates, free ammonia, and nitrites.

10. *Silicate content* was measured by the method of Diénert and Wandenbulcke (1923).

11. *Free ammonia* was measured by direct Nesslerisation (Amer. Publ. Health Assn., 1925, p. 16). In this estimation the difficulty arose that the waters often became turbid when the Nessler reagent was added directly to the sample. Accurate estimation of the colour was then impossible. The samples were therefore first treated with alkali and CuSO_4 , and the precipitate filtered off. After this treatment there was no turbidity when the Nessler reagent was added. Some, but not all, of the colour was removed.

12. *Nitrate content* was measured by reduction to ammonia in the presence of acid (Thresh and Beale, 1933, p. 240). Both a Zn-Cu couple and Devarda's alloy were used for the reduction.

13. *Nitrite content* was measured by the Naphthylamine method (Amer. Publ. Health Assn., 1925, p. 18).

14. *Organic nitrogen* was measured by Kjeldahl's method (Amer. Publ. Health Assn., 1925, p. 17).

15. *Chlorides* were measured by titration with silver nitrate, using Potassium chromate as an indicator (Amer. Publ. Health Assn., 1925, p. 42).

16. *Penetration of light*. A Bernheim photo-electric cell was used. It was enclosed in a metal box having a quartz window. Light of different parts of the visible spectrum was separated by three colour filters, which were placed over the window of the box. The sensitivity curve of the cell and the absorption curves of the filters have been given in a previous paper (Carter, 1934). The results are expressed as percentages of the light in full sunlight.

THE SOURCES FROM WHICH THE WATERS WERE COLLECTED.

Rivers.

At the Mazaruni Station the united stream of the Mazaruni and the Cuyuni is a broad river about a mile wide. Its maximum depth is a little more than 30 ft. The bottom is sand, which is muddy in places. Large parts of the shores are muddy, and in such places near and below the Station the shores are covered with mangroves, but this is not so higher up the river. Wherever the forest has not been cut, the trees overhang the bank and the river flows through their lowest branches. In many places the forest grows on swampy ground, which is often flooded by the river.

The first falls on the Cuyuni are at Camaria, a place about five miles above the Mazaruni Station. Here the river passes a series of six small falls and numerous rapids in a distance of about three miles. Below the falls the river is tidal with a rise and fall of about 8 ft. The current, at its maximum, is about 4 miles an hour, but it varies with the amount of water coming down the river. The tide reverses the current for about four hours out of the twelve.

The samples from the river at the Mazaruni Station were collected in the centre of the river, usually at high tide.

Above the Camaria falls the Cuyuni, where it is not broken up by the numerous islands, is about half a mile broad. The banks are here entirely forested and parts of the forest near the banks may be flooded to a depth of one or two feet. The speed of the current is variable. It is usually between three and five miles an hour.

The camps at which the analyses were carried out in July were made on the banks of the undisturbed stretch of the river, 12 miles long, between the first and second series of falls. Camp I was on the southern bank, six miles above the top of the Camaria falls and near the mouth of a large stream called the Oko Creek. Camp II was also on the southern bank but close to the falls at the upper end of the undisturbed water. Camp III was on the northern bank, almost opposite Camp I and near the mouth of another large stream, the Akarabisi Creek.

A photograph of the Cuyuni in these regions is given in fig. 1, Pl. 1.

The Demerara at Mackenzie is a smaller river than the Cuyuni, being two or three hundred yards across. It also differs from the Cuyuni in being undisturbed by falls for about fifty miles above Mackenzie. Its water is therefore much less disturbed than that of the Cuyuni. Its current is as rapid as that of the Cuyuni and the river is tidal. The banks are forested and the bottom sandy.

Streams.

In these districts of Guiana the forest stands on ground which is almost everywhere slightly undulating. It rises, between the rivers and streams, to watersheds at a few hundred feet above the level of the rivers.

Throughout the forest, wherever the ground has no slope, it is liable to become sodden or flooded in wet weather. Such places are frequent, especially in the lower parts of the forest near the river. On much of the lower ground, water may collect to a depth of six inches or a foot. The forest streams are fed either from these flooded areas or by rivulets which flow off the higher ground. The streams are numerous. It is usual to pass a stream almost every mile as one walks through the forest.

At some distance from the river, where the land rises towards the watersheds, the slopes are generally steeper than in the lower country near the rivers. On the higher ground the streams are small with a swift current, flowing sometimes between definite banks and sometimes through the centre of a belt of flooded forest (Pl. 1, fig. 3). Nearer the river they become more sluggish (fig. 2) and the flooded forest on their banks is broader and more frequent. Where the streams are small, the canopy above them is closed. This is almost always true of the fast-flowing streams of the higher ground and is often true of the whole course of the stream to the river. A large stream may, however, be 20 or 30 yards wide at its mouth and, where this is so, the canopy is broken and the water of the stream is exposed to almost full sunlight.

The subsoil of the forest varies from a very pure sand to clay. It is covered by a thin layer of soil and a layer of decaying leaves, which is always thin and usually not more than a few leaves thick. The bottom over which the streams flow is determined by the nature of the soil and the speed of the current. It is usually sand in the more rapid streams, where it is scoured by the current, and becomes muddy in the slower parts of the streams near the river.

There are two types of forest stream. These types are distinct, although streams intermediate in type occur. One of these types, the 'white-water' streams, flows from areas of Mora or Mixed Forest (pp. 150-1, above). Their water is almost colourless and frequently slightly turbid. The second type, the 'black-water' streams, have dark yellow water, which is always clear. These black-water streams are popularly supposed to derive their colour from the decaying leaves of the Wallaba (*Eperua* spp.), and it is certainly true that many streams of this type flow from Wallaba forest. There is undoubtedly some

correlation between forest containing a large proportion of Wallaba and the colour of the streams which flow from it, but it is not established that the coloration of the water is due to pigment set free from the decaying leaves, as it is usually supposed to be. Further, the black-water streams do not always flow from Wallaba forest. The water of the forest swamps are as dark as any in Guiana, although there may be no Wallaba growing near them. These swamps are undoubtedly one source of the black water.

Analyses were made of the water of several white-water streams near the camps on the Cuyuni in July. Water from both the lower and the upper parts of these streams was analysed. In the Cuyuni district only two black-water streams were examined. One of these was the Baracara Creek which flows into the Mazaruni near its junction with the Cuyuni, and the other was a stream in Wallaba forest near Camp III. Both were small fast-flowing streams.

The streams flowing into the Demerara near Mackenzie are all black-water streams. Two of these were examined. Both were large streams. The water was taken from them not far from their mouths, but far enough up the streams to ensure that it was stream water and not water of the river that was collected.

A stream named Karow Creek near the Mazaruni Station (Pl. 1, fig. 3) was intermediate in type between the typical white- and black-water streams, both in colour and, as we shall see, in the chemical nature of its water. It was a fast stream flowing over a sandy bottom through swamp forest. There can be no doubt that the intermediate colour and chemical nature of the water is due to its being partly white and partly black in origin.

Swamps.

The forest swamps are covered by the swamp forest which has been described above (p. 151). They must be distinguished from the areas of flooded forest in which the water on the ground is less permanent and the vegetation is not essentially different from that of drier parts of the forest near by.

A photograph of a typical forest swamp is reproduced in Pl. 2, fig. 4.

The swamp is usually not more than two feet deep and its bottom is formed either of a deep layer of decaying leaves or of soft fine mud. The water is very yellow. Since it is covered by forest, the water is entirely undisturbed by wind.

A swamp of this type four miles north of the Mazaruni Station was examined, and another near Camp III on the Cuyuni. The latter (fig. 4) is called the Manicole Swamp in the following pages, from the prevalence of the Manicole palm among the trees above it.

Grass swamps are rare in undisturbed forest in these districts, although they are common in other parts of Guiana. Near the Mazaruni Station grass swamps are found in some places where the forest has been destroyed by fire. Photographs of one swamp of this type (called Swamp A in the following pages) are given in fig. 5, Pl. 2. This swamp was used for many observations on account

of its convenient situation near the Station. The surface of the water was almost everywhere covered by a thick growth of grasses and ferns to a height of five feet, but there were some open pools. The bottom of the swamp was fine mud. The water was very yellow and at most two feet deep.

In wet weather these swamps may be drained by streams; in dry weather many of them are stagnant. At the height of the wet season most of the water of Swamp A was in motion, but stagnant pools could still be found. One pool on the course of a stream from another grass swamp near the Mazaruni Station was also used for many observations. This pool is called pool B below. It was stagnant in dry weather, but there was a stream across its surface after rain. It was about four feet deep, with a bottom of soft mud and with much herbaceous vegetation in the water around its edges. The centre of the pool was open (fig. 6, Pl. 2).

Occasional observations were made in other localities in addition to those here described. These localities will be described where it is necessary to refer to them in the discussion of the results.

FLORA AND FAUNA OF THE WATERS *.

It is necessary that a summary description of the animals and plants living in these waters should be given here in order that the effects produced by the life of this flora and fauna upon the chemical nature of the waters may be discussed later in the paper. But it is not proposed to describe the flora and fauna in more detail than is required for this purpose. It is hoped that a more detailed account will be published in later papers.

In all the waters fishes, crustacea, and other large animals are almost always to be found in considerable numbers and in great diversity of species. But the larger animals need not here detain us, for their numbers are never sufficient to cause appreciable modification of the chemical character of the waters in which they live. Nor need we be concerned with the aerial plants, except in so far as they deprive the water of light, and their effects in this respect have been mentioned in the preceding sections.

Where the water is sufficiently lighted and shallow, aquatic plants are often present in large numbers. This is especially true of the grass swamps and the swamp pools, in which *Sphagnum* may occur plentifully, and algae, either green or blue-green, are present in considerable quantities. In the grass swamps desmids are also plentiful. Diatoms are rare in the stagnant waters. In the forest swamps truly aquatic vegetation is much less than in the grass swamps, probably as a result of the low illumination.

The stagnant waters everywhere contain a large amount of dead vegetable matter, and bacterial decay is undoubtedly active both in the water and in the mud or leaves at the bottom of the water. That this is so is shown by the

* I am indebted for most of the data of this section to Mr. T. G. Tutin of Downing College, Cambridge, who was a member of the expedition.

large amount of gas which escapes whenever the bottom of the swamp is disturbed. In most places this gas is carbon dioxide (but see p. 169 below).

The strong currents of the flowing waters are sufficient to prevent the development of an indigenous plankton. But on the mud at the bottom of the streams and in the shallower parts of the rivers sessile diatoms are often found in large numbers. Green and blue-green algae may also be found on the mud in the streams, especially in the dry season. The only planktonic plants present in the water of the streams and rivers are a few forms apparently derived from the stagnant waters or from this bottom flora. It is to be expected that this derived plankton should increase in the wet season when the currents are faster, and it was found to do so, but its quantity is always very slight.

It is a noticeable characteristic of the water of the rivers and of many of the streams that they contain much fine plant debris. We found that there was usually so much debris in the water that the plankton net soon became choked with it. It cannot be doubted that this debris is rapidly decaying and therefore that it contains a large bacterial flora.

The animal plankton of all the forest waters is slight in quantity. In the stagnant waters there is a small but varied plankton including Cladocera, Copepoda, Ostracoda, insect larvae, Rhizopoda, and other forms. Rotifers are conspicuously rare. Of these groups the Rhizopoda are the most characteristic and are found in almost every sample. Numerous species of *Difflugia*, *Arcella*, and related genera occur.

In the rivers and streams the only animal plankton consists of a few forms washed from the stagnant waters, and of some Rhizopoda among the plant debris. This animal plankton is negligible in amount.

It will be clear from this account that in the stagnant waters the algae, the desmids, and the bacteria are the only organisms which are present in sufficient numbers to influence the chemical nature of the water. In the rivers and streams only the bacteria are sufficiently numerous to do so.

In the swamps there is considerable seasonal variation in the plant plankton. There are no similar variations in the plankton of the rivers and streams, nor in the animal plankton of the swamps. The plankton of the grass swamp A was most thoroughly investigated, and the facts given here refer to that swamp, but the succession seems to occur in most of the open swamps. The seasonal variations of the plankton of the forest swamps were not examined.

At the beginning of May, when the swamp was low, blue-green algae were abundant and filamentous desmids were plentiful. As the swamp rose during May, the blue-green algae were replaced by filamentous green algae, and these remained dominant during the wet season (June and July), when the swamp was full. By the beginning of August, when the weather had again become dry and the swamp had fallen, blue-green algae had reappeared and were almost as plentiful as at the beginning of May. The desmids remained abundant during the whole period. Dinoflagellates were not found in this swamp, but they occurred plentifully in some other shallow waters.

RESULTS.

(a) ANALYSES.

The results of the analyses of the mineral content and electrical conductivity of the samples which were brought back to England will be first considered. After this, we shall go on to discuss the analyses made in Guiana. The full data of the analyses are given in Appendices I and II.

(1) *Mineral content and electrical conductivity (Appendix I).*

In the first appendix the results of analyses of silica and chloride content carried out in Guiana are given alongside the results which were obtained from the water samples brought home. The figures given for the silica and chloride contents are averages of all the analyses of these contents made in Guiana on waters from each type of source. Thus, in these figures results which were obtained at different times, and, some of them, in waters from more than one source have been averaged. The figures are therefore averages of results which are not strictly equivalent. They must be taken as giving no more than approximate values for the quantities of the constituents which it is reasonable to expect in each type of water.

Among the analyses of the water samples brought home, nos. 1, 4, 6, and 7 were obtained from two or three samples collected at different times and put together for analysis. These analyses are probably more accurate than the rest, which were made on single samples, but they must be considered as average values for the waters from these sources.

For convenience, analyses of typical hard and soft British waters have been placed at the foot of the table.

The agreement between the two sets of figures given for the silica content is probably as good as could be expected in view of the fact that the estimations were made in London and Guiana, not on exactly the same waters, and by different methods.

The results show that the mineral content is very similar in all the waters. This is confirmed by the figures given for the electrical conductivity, which may be taken to be proportional to the total mineral content. Very few of the differences between the analyses are large enough to be significant and none can have any biological importance. This is true even when the Demerara water is compared with the waters of the Cuyuni and Mazaruni, although the rivers are in different systems.

The only differences which may, perhaps, be significant are the higher sulphate content of the rivers as compared with the streams and swamps—for this it is difficult to give a reason—and the lower silica content of the swamps. The last difference is to be expected. The beds of the streams and rivers are mostly sand and those of the swamps fine mud or decaying leaves. Also, silica is washed out of the soil into the water and it is therefore to be expected that there should be more silica in water which had flowed for some distance.

It will be seen that the mineral content of the Guiana water is no greater

than that of the Loch Katrine water, which is among the softest of British waters. The electrical conductivity of the Guiana waters is also very low. Typical conductivities of soft waters lie between 40 and 100 recipr. megohms per c.c. and of hard waters between 500 and 1500. The conductivity of Loch Katrine water is 50 recipr. megohms per c.c. The conductivities of the Guiana waters are not, however, lower than some which Ruttner found in the waters of Javan Lakes (1931). He observed conductivities varying between 20 and 340 recipr. megohms per c.c. The lowest of these values is as low as that of rain water.

It should not be surprising that waters from tropical countries such as Java and Guiana contain little inorganic salt. The geology of both countries is igneous, and, in Guiana at least, the rocks are very poor in salts. It is perhaps equally important that in Java, as in Guiana, the rainfall is high and must greatly exceed the evaporation. We have seen that in Guiana the true evaporation quotient is not larger than 0.5. In both countries the land must be washed by a continuous current of water from the higher to the lower ground, and the surface soil must be continuously leached by this current. In Guiana the soil of the forest districts is known to be very poor both in salt content and in organic material. There can be little doubt that the strong leaching to which the forest is exposed is one cause of both the poverty of the soil and the low salt content of the water flowing from the forest.

(2) *The results of analyses carried out in Guiana.*

The results given in Appendix II have been summarised in the data of Tables I and II (pp. 166 & 167). In these tables averages of the results of all the analyses of waters of each type are given. It must be noted that the same considerations apply to these averages as to the averages of silica and chloride content given in Appendix I (p. 164, above). The figures marked with a * are even more roughly approximate than the rest. Reference to Appendix II will show that in these characters the waters were especially variable. Thus, the gas contents of the stream waters vary greatly with the speed of the current and other conditions, and those of the swamp waters are equally variable, although the conditions which control them are different. These conditions will be discussed later in the paper.

The tables are not intended to replace the Appendix, to which reference will often be made.

a. *Chemical characters of the waters in general.*

Apart from their low mineral content the most striking characteristic of the Guiana waters is their yellow colour, which is often so pronounced that, when the water is seen by reflected light in a stream or river, it looks coffee-coloured or even chocolate-brown. It will, also, be seen from the figures of Table I that, besides carbon dioxide, much other free acid is present in many of the waters. The largest amount of free acid recorded was 9×10^{-4} N. The results show that the amount of free acid present is correlated with the depth of the colour.

TABLE I.—*Analyses of Guiana fresh waters.*

Averages of gas contents, reaction, etc.

Source.	Weather.	Turbidity.	Colour.	pH.	Dissolved oxygen.		Free carbon dioxide, c.c. per l.	Other free acids, N/10 ⁻⁴ .	Alkali reserve, N/10 ⁻⁴ .	
					c.c. per l.	Satn. Deficiency, per cent.				
<i>Rivers.</i>										
R. Mazaruni	Dry	tr. —26	slight	6.68	4.39	20	1.15	abs.	0.54	
"	Wet	27	"	6.10	4.59	21	1.80	1.11	0.80	
"	Flood	55	"	6.45	4.86	17	7.29	0.56	1.93	
R. Cuyuni	Wet	clear —43	"	6.2	4.62	20	2.56	1.00	1.22	
R. Demerara	Wet	clear	moderate	5.45	3.48	40	3.30	1.43	0.39	
<i>Streams.</i>										
White water, .....	..	clear —37	v. sl. —none	6.02	3.53 *	37 *	6.24 *	0.34	1.68
Intermediate (Karrow Creek)	Dry	clear	moderate	5.82	3.87	33	4.81	1.54	0.66	
" "	Wet	"	"	5.66	3.20	47	5.45	1.74	1.12	
Black water .....	..	"	strong	4.5	3.48 *	45 *	5.12 *	3.01	0.11
<i>Swamps, Pools.</i>										
Grass swamp A	Dry	clear	strong	4.42	0.22 *	96 *	8.37 *	1.94	abs.	
"	Wet	"	"	4.45	1.24 *	80 *	9.18 *	4.75	abs.	
Other swamps .....	..	"	"	4.53	0.65	85	13.48	3.17	0.49
Pool B	Dry	"	"	4.07	0.60 *	87 *	12.73 *	6.92	abs.	
"	Wet	"	"	4.15	1.45 *	77 *	5.02 *	4.75	abs.	

* Very variable.

TABLE II.—*Analyses of Guiana fresh waters.*
Averages of organic content, chlorides, etc.

Source.	Weather.	Phosphates, mg. PO ₄ per l.	Silicates, mg. SiO ₄ per l.	Free Ammonia, mg. N per l.	Nitrates, mg. N per l.	Nitrites, mg. N per l.	Organic Nitrogen, mg. N per l.	Chlorides, mg. Cl per l.
<i>Rivers.</i>								
R. Mazaruni	Dry	0.06	4.3	0.03	0.15	0.003	0.20	3.7
"	Wet	0.07	4.4	0.04	0.20	0.002	0.31	1.7
"	Flood	0.125	4.0	0.05	0.14	0.002	0.09	0.4
R. Cuyuni	Wet	0.14	5.0	0.02	0.15	0.001	0.125	2.5
R. Demerara	Wet	0.06	5.0	0.07	0.12	abs.	0.45	2.8
<i>Streams.</i>								
White water .....	..	0.11	8.0	0.10	0.10	0.002	..	3.6
Intermediate (Karrow Creek)	Dry	0.10	5.5	0.11	0.24	0.0015	0.12	5.3
" ..	Wet	0.06	6.6	0.15	0.19	0.001	0.29	3.6
Black water .....	..	0.06	5.0	0.10	0.23	0.0015	0.21	2.5
<i>Swamps, Pools.</i>								
Grass swamp A	Dry	0.06	3.2	0.26	0.10	0.0005	0.80	1.6
"	Wet	0.075	3.2	0.12	0.05	0.001	0.13	2.5
Other swamps .....	..	0.18	5.4	0.10	0.10	0.004	0.14	1.7
Pool B	Dry	0.035	3.9	0.50	0.16	0.002	0.29	6.3
"	Wet	0.035	3.8	0.21	0.16	0.001	0.25	2.4

As a result of the presence of free acid and of carbon dioxide, the pH of all the waters is acid. The acidity of some of the waters is very great. The most acid water examined was of pH 3.9.

In contrast with the mineral content, the amount of organic matter in the waters is considerable. For all the waters, an average of 0.1 mg. of phosphate per litre was found. This would be high for temperate waters and is considerably higher than the quantities found in the surface waters of Javan lakes by Ruttner (1931, average 0.03 mg.). In the lower waters of the lakes, which were cut off from the surface by permanent stratification, much higher figures were obtained, but it is clearly not with these isolated waters that most of the Guiana waters should be compared.

The average content of free ammonia (as nitrogen) for all the Guiana waters was 0.15 mg. per litre. This is also somewhat high. It is slightly higher than Ruttner found in the surface waters of the Javan lakes (average about 0.1 mg.). It is approximately equal to the maximum values found in uncontaminated British rivers (Itchen, 0.05–0.15 mg., Butcher, Pentelow, and Woodley, 1928; Wharfe, trace—0.16 mg., Pearsall, 1930 *a*). It is of the same order as the content of the surface water of Lake Mendota (0.10 mg., Domogalla, Juday, and Petersen, 1925), a definitely eutrophic lake. The nitrate content (average about 0.17 mg. N) is at least as high as that of Lake Mendota and about equal to the maximum observed by Pearsall (1930 *b*) in English oligotrophic lakes of the Lake District. The organic nitrogen (average about 0.25 mg. N) is somewhat lower than that of Lake Mendota (0.4 mg.). The silica content is moderately high. This condition is clearly a result of the nature of the soil.

These waters from Guiana have, therefore, as a whole, the following characteristics :—

1. Low mineral content.
2. Frequently a strong yellow colour.
3. High acidity.
4. Somewhat high contents of phosphates, nitrogen compounds, and silica.

b. Chemical differences between the waters from different sources.

We have seen that there are two types of stream in these forests, the 'black-water' streams which drain the swamps or flow from Wallaba forest, and the 'white-water' streams which flow from Mixed and Mora forests. The waters of these types of stream differ in other characters besides their colour, and it is therefore necessary to consider separately these two types of water and the swamps and streams which contain them.

1. Swamps and black-water streams.

The only observations in Wallaba forest were made in its larger streams; the waters at the source of the black-water streams of the Wallaba forest were not examined. We have therefore only the swamps to consider as the origin

of the black water. Some forest swamps were examined, but the greater number of the observations in swamps were made in the grass swamp A and the pool B.

The swamp waters (nos. 51-75 *) are all highly acid, the acidity being partly due to free carbon dioxide, which is almost always plentiful (4-36 c.c. per litre), and partly to other free acids, of which there is also usually much ($0.8-9.3 \times 10^{-4}$ N). Alkali reserve is almost always absent owing to the acidity. The oxygen content is low, the saturation deficiency hardly ever falling below 70 per cent. even in the surface water, and sometimes rising to 100 per cent.

It has been noted above that there is always much gas in the mud or leaves which form the bottom of the swamps and that the presence of this gas shows that bacterial decay is active there. Since this is so, the mud and leaves must be even more strongly deoxygenated than the water above them. A smell of hydrogen sulphide was observed in the gas rising from the deep layer of leaves at the bottom of the Manicole swamp (64), but it was never observed in other swamps.

The variations in the oxygen and carbon dioxide contents of the swamp waters are considered further below (p. 175 ff.).

In the dry weather the swamp waters have high contents of ammonia and organic nitrogen, but these contents fall greatly in the wet season, when there are usually streams through the swamps. The nitrate content is always below the average for the Guiana waters. So, also, is the silica content.

In most of the swamps the phosphate content is not higher than in other types of water, but the Manicole swamp (64) was an exception to this, being very rich in phosphates (0.53 mg. per litre). It may be noted that the Manicole swamp differed from all the other swamps examined in Guiana in being without an outlet, even in the wet weather. In this respect it resembled the Paraguayan swamps previously investigated, which were almost completely enclosed (Carter and Beadle, 1930). The high phosphate content of the water of the Manicole swamp is also an approach to the condition of the Paraguayan swamps (1-11.5 mg. per litre). It seems that phosphates accumulate in these tropical stagnant waters, when they are not removed by currents or by animal and plant life. They are probably derived from the land from which they are leached (Carter and Beadle, 1930, p. 244), and the amount of phosphate will clearly be less where the soil is poor, as it is in Guiana. Ruttner (1931) found moderately high phosphate concentrations (up to 0.4 mg. per litre) in the isolated lower waters of the Javan Lakes.

The seasonal changes in the plankton of the swamps are those to be expected in view of the nature of the seasonal changes in the water. The replacement of the blue-green algae, which are dominant in the dry weather, by green algae as the swamp rises in the rainy season is clearly associated with the fall in the organic content of the swamp water at this time.

* These numbers refer to the second Appendix.

The water of the streams flowing from the swamps (29, 30) differs from the water of the swamps themselves chiefly in being better aerated, although the oxygen content is still far from saturation (deficiency 49 per cent. or higher). Carbon dioxide is also plentiful in the water of these streams (6–7 c.c. per litre). In these and all other types of the stream, the gas contents are variable, being determined by such conditions as the rapidity of the current.

The only marked differences between the streams from Wallaba forest (28, 31–33) and those from the swamps were the better aëration of the Wallaba streams and the somewhat higher nitrate and lower ammonia content in their water. These latter differences may be due to differences in the waters at the source of the streams or, more probably, to the fact that the samples from the Wallaba streams were taken farther down the streams. Nitrates are representative of a later stage in the process of decay than ammonia, and it is to be expected that they would increase, and ammonia decrease, as the organic substances in the stream water were altered by decay.

Thus, the chemical characters of the waters of the black-water streams are those to be expected in water which is in origin swamp water or very similar to swamp water, and which has been aerated and to some extent chemically altered on its way down the stream.

2. *White-water streams.*

Analyses nos. 46, 47, 49, 50 may be taken to represent the water at the source of the white-water streams. These analyses were made on water from small pools in Mora forest. The pools were heavily shaded, very shallow, usually with a muddy bottom and with very little animal and plant life. The streams are, however, largely fed by rain-water which has flowed directly off the forest and never collected into stationary pools.

These pools were never as completely deoxygenated as the swamp waters, probably because their very shallow water is frequently disturbed by rain. They have an oxygen deficiency of 60 per cent. or higher, and a somewhat high carbon dioxide content (6·5–8·8 c.c. per litre).

Analyses 40–45, 48 give the characters of the water of the white-water streams, which are fed by such pools as these. The water of these streams are better aerated than those of the pools (oxygen saturation deficiency 37 per cent., carbon dioxide content 6·25 c.c. per litre) and are consequently less acid, but in other respects the waters of the streams and pools are very similar.

In addition to the difference in colour, the white waters differ from the black in the following characters :—

(1) They are frequently slightly turbid. This may be due to the fine mud over which many of the white-water streams flow.

(2) Free acids other than carbon dioxide are typically completely absent. They are never present in more than very small amounts. As a result of this the pH is higher (pH 5·9–7·0) and the water contains more alkali reserve,

(3) The silicate content is considerably higher.

(4) The phosphate content is somewhat higher and the nitrate content lower.

The oxygen and carbon dioxide contents of the two types of streams were approximately equal. It was noticeable, however, that the larger white-water streams were often well oxygenated, although their current was sluggish. This was, perhaps, due to the small quantity of plankton in the water.

3. *Intermediate streams.*

Only one stream with water intermediate in colour between the typical white and black waters was examined. This was Karow Creek near the Mazaruni Station. A series of analyses (34-39) were made of the water of this stream, partly with the object of determining the chemical nature of water of this type, and partly in order to observe the nature of the seasonal changes in the water of a stream.

In chemical characters, as in colour, this water was intermediate between the white and black waters. The average contents of free acid other than carbon dioxide, pH, alkali reserve, phosphate, silicate, and nitrate all lay between the average values for white and black waters. The aëration of the water was about equal to that in the other types of stream.

The analyses of the water of this stream made at intervals during the wet season showed little consistent seasonal change. Many of the chemical characters of the water were variable, but the variations were irregular. It is probable that this was due to variations in the proportions of the water coming from different types of source. The analyses of the river water to be given below will show that consistent seasonal changes do occur in the waters of the country as a whole.

4. *Rivers.*

Analyses nos. 1-27 were made on various samples of river water. The 'river swamp' (26, 27) consisted of flooded forest near the banks of the Cuyuni and its water was more akin to the river water than to the water of the true forest swamps. This water is therefore included among the river waters. The general characters of the river water will be considered first and their seasonal variations later.

In all the rivers which were examined the water was found to be completely disturbed. This was clearly the result of the current and, in tidal rivers, of the tide. The complete disturbance is shown by the absence of any but very small differences between the surface and bottom waters. It is also shown by the low saturation deficiency of oxygen (about 20 per cent.) and except on rare occasions, by the low carbon dioxide content. The higher carbon dioxide content in the water of the Mazaruni on June 6 is discussed below.

The chloride content of none of the river waters is significantly greater than that of other types of water. There is clearly no mixture of the water of the tidal rivers with sea-water at the places where the observations were made,

The river water is only slightly coloured. This is in part a natural result of the fact that the rivers are fed by both white- and black-water streams, but it is also clear that the free acids of the stream water (and with the acids the associated colour) are reduced in amount as the water flows down the streams and river, presumably by chemical destruction. That this destruction takes place is shown by the complete absence of free acid in the water of the Mazaruni in dry weather.

As a result of the better aëration of the water (and consequent reduction of the carbon dioxide content) and of the reduction of the free acid present, the pH of the river water is higher than that of the streams.

Nitrogen compounds are present in about the same amount in the rivers as in the streams, except that the content of free ammonia is much less. The phosphate content is also about equal to that of the streams. The silicate content is lower than that of most of the streams which were examined, but it must be remembered that the rivers are fed from other districts besides those in which the work was done. In other districts the water of the streams may contain less silica.

The analyses of the water of the Cuyuni above its first falls (16–23) showed it to be very similar to the water of the river at the Mazaruni Station under similar conditions of weather.

The two analyses which were made of the water of the R. Demerara at Mackenzie are interesting as showing the condition of the water in a Guiana river at a considerable distance from falls and rapids. This water showed a larger saturation deficiency of oxygen (40 per cent.) than the Mazaruni and Cuyuni waters, and the content of free carbon dioxide (3.3 c.c. per litre) was higher than in the Mazaruni water under similar conditions of weather.

It is not likely that any of the Guiana rivers become more deoxygenated in wet weather than these analyses show the Demerara to be at the time of the observations—namely, at the end of the wet season. In the dry season, when the currents are less, the deoxygenation of some of the rivers may be greater.

The water of the Demerara is more acid and more strongly coloured than that of the Mazaruni, probably because most of the streams which flow into it contain black water.

Analyses nos. 1–15 of the water of the Mazaruni at the Mazaruni Station show the extent and character of the seasonal changes which occur in the waters of these rivers. The changes are marked, but not simple. We will first consider the rise of the river from its low state at the beginning of May to the normally full condition which it reached in the latter part of May and to which it returned in the middle of June. At the beginning of June the river was abnormally flooded for a short time (nos. 9, 10), and the condition of the water at that time will be considered afterwards. By the beginning of August the river had fallen and its water was then returning to the condition in which it was at the beginning of May.

As the river rose in May, the dilution of the water due to the increased rain was shown by the fall in the chloride content. Other changes in the water

occurred at the same time. Turbidity, which was absent when the river was low, appeared ; it was probably derived from the turbidity of the white-water streams, less time being allowed for suspended matter to settle when the river was full. Free acids also appeared in the river water at this time, and the contents of carbon dioxide and alkali reserve rose. All these changes are to be expected if, when the river is high and the current swifter, the river water is more similar to the waters of the streams.

When the Mazaruni was flooded (June 6, nos. 9, 10), its water differed in several respects from its condition when the river was lower. The condition of the water at this time can be explained in most respects by an exaggeration of the changes which had previously occurred as the river rose after the dry season. This is true of the chloride content, turbidity, alkali reserve, and carbon dioxide contents, although the last is surprisingly high. Perhaps, this high carbon dioxide content was due to washing out of carbon dioxide from the stagnant inland waters. On the other hand, the pH returned to a higher value in the flood water, there being less, and not more, free acid present than before the river became flooded. Probably this was due to dilution, caused by the large amount of rain which was then falling on the country. If, as must be supposed, the acid is formed in the swamps and the Wallaba forest from decaying vegetation, it is to be expected that it will be washed away and the supply fail, when the rainfall is great.

The considerable increase in the phosphates in the flood water is not easily interpreted. It may be compared to the similar increase in the Paraguayan swamps after heavy rain (Carter and Beadle, 1930). Perhaps, parts of the land, which normally supply little water to the river, are washed at such times and form a source for the supply of more phosphates.

(b) PENETRATION OF LIGHT.

The intensity of the light at different depths in the various waters was measured by means of the Bernheim cell. Several sets of these observations were carried out. Results obtained in the river water and in the water of an open swamp pool are given in text-figs. 2 and 3.

In the figures the curves give the percentages of the light of full sunlight which penetrates to different depths. Separate curves are given for the total visible light (NF) and for the light received through the red, green, and blue filters (RF, GF, BF). In the lower parts of the figures (A) the percentages are expressed on an arithmetic scale and in the upper parts (B) on a logarithmic scale.

The observations in the water of the river (fig. 2) were made in the centre of the river and the instrument was held as far as possible from the boat, so that any danger of shading by the boat might be avoided.

It will be seen that the absorption of the light is rapid. This is clearly due to the colour of the water and the large amount of debris in it. There is considerable differential absorption of the light in the different parts of the spectrum ; the red light penetrates considerably farther than the green or blue.

Pearsall and Hewitt (1933) found that in Lake Windermere the total visible light at the lower limit of vegetation was about 0.2 per cent. of full daylight. In Guiana the sunlight is about 50 per cent. stronger than in England, and it is

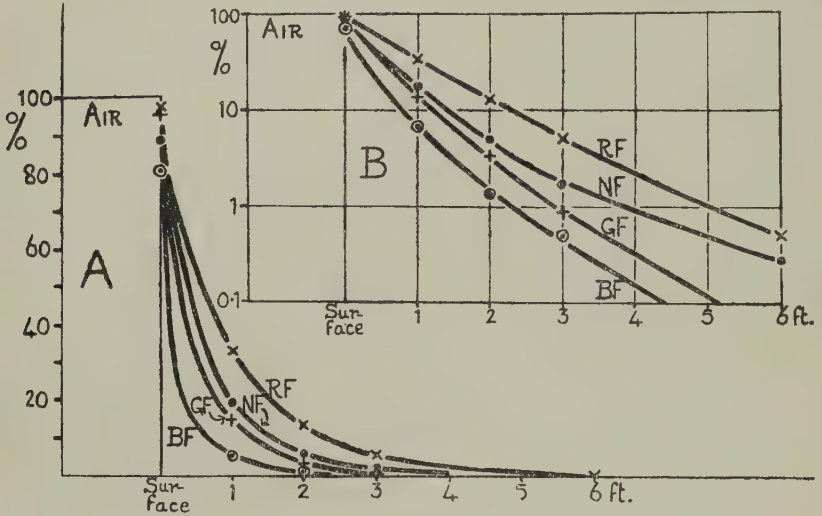


FIG. 2.

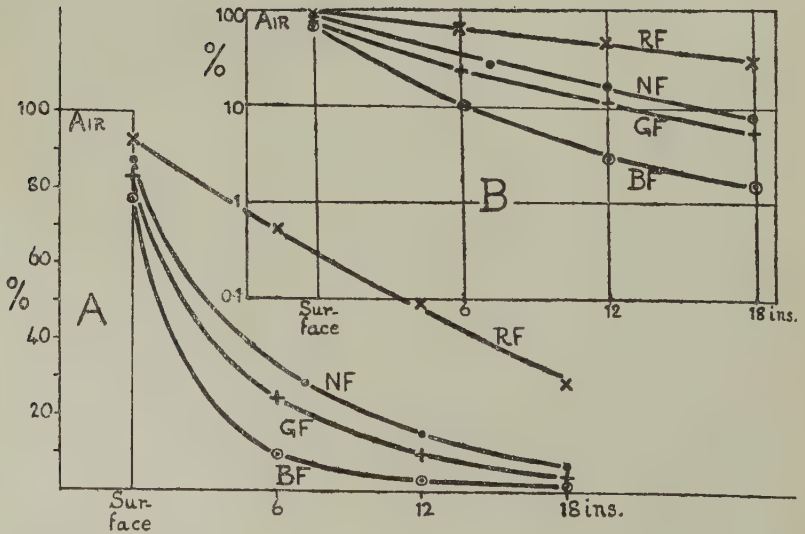


FIG. 3.

possible that a slightly lower percentage than 0.2 per cent. might support plant life in the water. In the river water the visible light would be reduced to 0.2 per cent. of daylight at a depth of about 7 ft. Active plant life is there-

fore only possible in the upper 7 or 8 ft. of the river water. At this depth the red light, which is the most important for photosynthesis, would be about 0·3 per cent. of that in sunlight.

It may be noted, in confirmation of these conclusions, that the percentage of sunlight in the illumination of the ground in the darkest forests in Guiana was found to be about 0·4 per cent. (Carter, 1934). In that position the vegetation is clearly living in illumination which is near the minimum for its growth. It is interesting that the amount of light present in the forest shade is in approximate agreement with the amount which Pearsall and Hewitt found at the lower limit of vegetation in Lake Windermere.

Fig. 3 gives the results obtained in a swamp pool exposed to direct sunlight. Observations made in other pools gave similar results. In this pool, as is general in the swamps, the colour of the water was darker than in the river, but there was little floating debris present. The absorption of the light was about as rapid as in the river water. The red light again penetrated farthest.

It will be seen that in such open pools there must be more than enough light for plant life at a depth of two feet, which is approximately the maximum depth of the swamp pools. But almost all the swamps are shaded either by the forest canopy or by vegetation of grasses and ferns growing above the surface of the water. The light at the surface of the water is therefore very much less

TABLE III.—*Fresh waters of British Guiana.*

Diurnal changes in swamp pools.

Date. Time.	Oxygen.		Carbon dioxide.		Temperature.	
	Surface, c.c. per l.	Bottom, c.c. per l.	Surface, c.c. per l.	Bottom, c.c. per l.	Surface, ° C.	Bottom, ° C.
1933.						
Open Pool. (18 ins. deep.)						
May 19 9.0 a.m.	0.47	0.16	8.30	13.66	25.5	25.5
2.15 p.m.	1.02	0.99	7.42	14.74	27.1	26.8
6.30 p.m.	0.82	0.48	8.83	16.49	26.9	26.4
May 20 8.30 a.m.	0.51	0.00	9.50	14.76	26.3	25.5
Open Pool. (12 ins. deep.)						
May 23 8.30 a.m.	0.71	0.36	7.95	9.99	25.8	24.4
2.30 p.m.	1.68	1.38	6.89	7.07	26.7	26.1
May 24 9.0 a.m.	1.08	1.00	6.92	7.53	25.0	24.9
Shaded Pool. (15 ins. deep.)						
May 23 8.30 a.m.	0.41	0.42	8.24	8.53	25.3	24.4
2.30 p.m.	1.16	1.00	7.27	7.59	26.2	26.0
May 24 9.0 a.m.	0.79	0.54	7.74	7.65	24.9	24.8

than full sunlight. In a typical forest swamp, such as the Manicole swamp previously described, the total illumination at the surface is about 1 per cent. of sunlight; in the grass swamp it was 3 per cent. When the reduction of the light at the water surface is taken into account, the results given in fig. 4 show that the total visible light would be reduced to 0.2 per cent. of sunlight at 10 ins. in the Manicole swamp and at somewhat more than 18 ins. in the grass swamp.

Thus, in the forest swamps the lower layers of the water are not sufficiently lighted for plant growth. In the grass swamps plants can probably live in all layers of the water, but in the lower layers the light is near the minimum for active photosynthesis.

The shade at the surface of the streams is variable. The smaller streams, being covered with a canopy, are under almost the same lighting conditions as the forest swamps. In the larger streams the illumination of the water approaches more nearly the conditions in the river.

It is appropriate here to discuss the diurnal variations of oxygen and carbon dioxide content which occur in the stagnant waters. The forest swamps were not examined in this respect, but diurnal variations were found to occur in the waters of the grass swamps. Typical results are given in Table III (p. 175). A diurnal variation of about 0.5 c.c. per litre in the oxygen content is clearly shown. The results of the determinations of carbon dioxide content are less regular owing to the larger errors in the estimations, but the variation appears to be of about the same size. These results were obtained on days on which the water was not overturned at night (see below, p. 177).

The size of diurnal variations depends on the quantity of aquatic life in the water as well as on the amount of light available for photosynthesis. The diurnal variations in these waters are not large, and it has been noted that there was a considerable flora of algae and other aquatic plants in the waters. The smallness of the variations can, therefore, only be due to the weakness of the light. It is also noticeable that the oxygen content of the water falls off rapidly as soon as the light decreases during the afternoon from its midday maximum (May 19). Unless the amount of light present was near the minimum for plant life, it is unlikely that the oxygen content would decrease during full daylight.

(c) STABILITY AND OXYGENATION OF THE STAGNANT WATERS.

We have seen (Table I, p. 166) that the water of the swamps and pools is often very largely deoxygenated. In the wet season the average saturation deficiency in oxygen of the whole of the water of the swamps is about 80 per cent. On some occasions the lower layers of the water were entirely without oxygen, and, not infrequently, samples taken as near the surface as possible (within $\frac{1}{2}$ in.) contained not more than 0.5 c.c. of oxygen per litre (90 per cent. saturation deficiency). In dry weather the deoxygenation was even greater than in the wet season (average saturation deficiency, 96 per cent.).

So far, these results, obtained by the more accurate methods used in Guiana,

confirm the conclusions which were founded on the investigation of the swamps of the Paraguayan Chaco (Carter and Beadle, 1930), namely, that these and probably many other types of tropical swamp are characterised by deoxygenation of the water, which is sometimes almost complete. But the Guiana swamps did not remain deoxygenated for such long periods as the Paraguayan swamps were found to do, especially in the hot weather of the Paraguayan summer. The Paraguayan swamps form an even more anaërobic environment than those of Guiana. The reasons for this difference need discussion.

The amount of dissolved oxygen in natural waters is determined by the rate at which oxygen enters the water by diffusion, disturbance, or photosynthesis, and the rate at which it is removed by respiration and the chemical processes of decay. Well aërated waters are those in which the rate of entry is greater than that of loss : in poorly aërated waters the converse is true. In the swamps of both Guiana and Paraguay oxygen disappears from the water more rapidly than it enters it, so long as the water is stagnant and, as we shall see, the equilibrium of the water is stable. This is always true in the long run, but during the daytime the oxygen content may temporarily increase as the result of photosynthesis, provided the illumination is sufficient. The heavier the shade in which the water lies the less will be the oxygenation of the water. In warm and dry weather even open swamps may become almost completely deoxygenated both in Guiana and Paraguay.

The swamps of Guiana and Paraguay differ to some extent in their illumination and in other conditions, but the difference between them which seems most likely to be the chief cause of the more complete deoxygenation of the Paraguayan swamps is the difference in the climate of the two countries. The climate of the Paraguayan summer differs from that of Guiana most greatly in :—

- (1) The much higher day maximum of temperature.
- (2) The greater diurnal temperature range.
- (3) The lower relative humidity and consequent greater evaporation.
- (4) The less frequent rainfall.

Average figures for these differences are given in the following table :—

	Paraguay.	Guiana.	
		Open.	Forest.
<i>Temperature.</i>	° C.	° C.	° C.
Daily maximum	36	29·5	26·5
Night minimum	22	22	22
Diurnal range	14	7·5	3·2
<i>Relative humidity.</i>	per cent.	per cent.	per cent.
Morning	83	93·7	97
Midday	65	78·8	90
<i>Rainfall.</i>			
Interval between falls	7 days or more.	2 days.	

TABLE IV.—*Fresh waters of British Guiana.*
 Dissolved oxygen and carbon dioxide in the grass swamp A.

Date.	Oxygen.		Carbon dioxide.		Water temperatures.				Air temperatures.		Rainfall of previous 24 hours.		
	Surf., c.c. per l.	12", c.c. per l.	Surf., c.c. per l.	12", c.c. per l.	Minimum of previous night.		Maximum of previous day.		Min. of previous night. °C.	Max. of previous day. °C.	Ins.	Time.	
					Surf. °C.	12" °C.	Diff. °C.	Surf. °C.					12" °C.	Diff. °C.
1933.													
June 1.....	1.78	1.04	7.87	9.65	24.2	24.7	-0.5	27.6	27.2	+0.4	31.5	0.46	evening
2.....	2.03	2.23	7.55	8.22	24.9	25.2	-0.3	28.5	27.1	+1.4	30	0.01	..
3.....	1.65	1.68	4.90	7.74	24.6	24.9	-0.3	28.3	27.4	+0.9	30	0.15	12.30 p.m.
4.....	2.16	0.98	7.87	7.85	25.1	25.0	+0.1	30.5	27.6	-2.9	30	0.43	2.0 p.m.
5.....	2.03	0.98	8.86	9.89	24.8	24.9	-0.1	31.3	27.7	-3.6	30	0.00	..
6.....	2.27	1.99	7.11	8.73	24.4	24.9	-0.5	29.3	27.4	+1.9	30	0.56	afternoon.
7.....	1.69	0.96	6.62	8.32	24.2	24.2	0.0	28.9	26.3	+2.6	22	0.55	morning.
8.....	..	..	..	..	..	..	..	..	..	..	22	0.00	..
9.....	2.13	0.54	7.36	10.21	25.0	25.2	-0.2	33.0	28.2	+4.8	22	0.00	..
10.....	1.18	0.28	9.94	9.38	25.3	25.4	-0.1	32.2	30.2	+2.0	22	0.00	..
11.....	0.46	0.34	7.96	9.24	25.4	25.3	+0.1	32.0	28.1	+3.9	22	0.00	..
12.....	1.33	0.43	10.61	12.06	25.1	25.3	-0.2	32.9	28.2	-3.7	22	0.05	10.30 a.m.
13.....	1.90	0.26	7.92	11.60	24.1	24.0	+0.1	27.7	26.4	+1.3	22	1.32	night.
14.....	..	..	..	..	24.1	24.5	-0.4	27.3	27.0	+0.3	21	0.00	..
15.....	..	..	..	..	24.5	24.4	+0.1	28.0	27.5	+0.5	21	0.57	12.30 p.m.
16.....	..	..	..	..	..	..	..	..	..	..	21	0.00	..
17.....	..	..	..	..	..	..	..	..	..	..	21	0.14	12.30 p.m.
18.....	2.30	0.90	8.36	10.83	23.9	24.4	-0.5	26.7	25.9	+0.8	22	0.27	afternoon.
												0.00	..

In the discussion of the observations on the Paraguayan swamps (Carter and Beadle, 1930) it was concluded that one of the conditions which were necessary to produce the continuous deoxygenation of these swamps was the absence, which was usual in the warm nights of the Paraguayan summer, of any overturn of the layers of the water due to cooling of the surface. For many days at a time, overturn of the water by convection currents did not occur. On occasional cool nights it did occur and it was then accompanied by rise of the oxygen content of the water.

As a result of the smaller diurnal range of air temperature, the temperature gradient at midday is much less in the water of the Guiana swamps ($2^{\circ}5$ C. in a swamp 1 ft. deep) than in that of the Paraguayan swamps (8° C. in the same depth). Thus, it is clear that much less cooling of the surface is necessary in the Guiana swamps to produce overturn of the water at night. It is true that in Guiana the smaller diurnal range of air temperature must result in less cooling of the water at night, and that the high humidity must prevent any appreciable cooling by evaporation. Yet it seems to be the fact that, at least in the wet season, overturn at night does often occur in the Guiana swamps. In Table IV results of daily observations of temperature and of oxygen and carbon dioxide content in the Grass swamp A are given. The samples for analysis were always taken in the morning between 10 and 11 a.m.

The results show that there is often a higher minimum temperature in the bottom water than at the surface. Where a steep reversed gradient occurs, overturn must take place. The results given in the Table show that there was a rise in the oxygen content, especially in that of the bottom water, whenever the reversed gradient was greater than $0^{\circ}3$ C.

The maximum reversed gradient given in Table IV is $0^{\circ}5$ C. in 12 inches of water. It may seem surprising that so large a reversed gradient should ever occur in so short a column of water. But similar gradients have been observed in both temperate and tropical waters ($0^{\circ}5$ C., Saunders, Wicken Fen, Cambridgeshire, unpublished, $1^{\circ}3$ C., Beadle, 1932, Lake Naivasha, Kenya). It may again be surprising that the dissolved oxygen did not increase—and presumably overturn did not occur—when the temperature gradient was reversed but less than $0^{\circ}3$ C. It must be remembered that the lower layers of the water contain various dissolved substances in greater quantities than the upper layers. It may be that a gradient of this size is necessary to overcome their greater specific gravity. Beadle (1932) found a reversed gradient of $0^{\circ}15$ C. in a swamp at Kitoma (Kenya) associated with a low oxygen content.

Thus, it seems that there can be little doubt that the water is often overturned at night in the Guiana swamps in the wet season and that this is one of the most important ways in which oxygen reaches the lower water of the swamps. It does not occur every night, even in the wet season. That the oxygen content of the water rapidly falls in the absence of overturn is shown in the results given in Table V (p. 180), in which the absence of reversed gradient between June 24 and 28 is accompanied by fall of the oxygen content (see also June 6–10,

Table IV, p. 178). In the dry season the deoxygenation of the swamps is greater, and, presumably, overturn is rarer.

The conditions which control the presence of this reversed gradient on some nights and its absence on others are by no means easy to determine, probably because they are complex. The minimum air temperature varies little, being always close to 22° C. (Table IV). The amount of cooling which the surface water undergoes must therefore depend rather on the temperature which it had previously reached—that is to say, on the midday maximum of the previous day. This is more variable (Table IV), being determined more by the amount of heating of the water by sunshine than by the air maximum of temperature, which is almost as constant as the minimum air temperature. A low diurnal surface maximum in the water implies a small diurnal temperature gradient, and therefore greater probability that the surface water will be sufficiently cooled in the succeeding night to give a reversed temperature gradient. It will be seen that there is some, but not complete, correlation in the results of Table IV between a small diurnal temperature gradient and a large reversed gradient at night.

It has been noted above (text-fig. 1, p. 153) that rain during the day cools the air considerably. It must also cool the surface water and may lead to overturn, either at the time at which the rain falls or in the succeeding night. There is some correlation in the data of Table IV between rain in the daytime and a large reversed gradient in the succeeding night. Rain during the night has not the same cooling effect on the air (fig. 1) and must have less effect on the water. But this should not be taken to imply that heavy rain at night never increases the oxygen content of the water. In fact, it seems to do so either by simple disturbance of the water or by causing overturn (June 12, Table IV; June 24, Table V).

TABLE V.—*Fresh waters of British Guiana.*

Dissolved oxygen and carbon dioxide in the grass swamp A.

Date.	Oxygen.		Carbon dioxide.		Min. temperature of water in previous night.			Rainfall.	
	Surf., c.c. per l.	12", c.c. per l.	Surf., c.c. per l.	12", c.c. per l.	Surf. ° C.	12". ° C.	Diff. ° C.	ins.	Time.
June 21.....	1·32	0·81	8·22	10·03	24·2	24·0	+0·2	0·20	morning.
22.....	..	..	..	..	24·6	24·5	+0·1	0·00	..
23.....	..	..	..	..	..	..	..	2·36	night.
24.....	2·93	0·91	8·63	13·56	23·9	23·9	0·0	0·76	night.
25.....	..	..	..	..	24·6	24·4	+0·2	0·00	..
26.....	1·18	0·81	7·42	10·21	24·7	24·4	+0·3	0·00	..
27.....	..	..	..	..	24·9	24·5	+0·4	0·00	..
28.....	0·49	0·33	11·46	16·70	25·2	24·7	+0·5	0·00	..

It is probable that other conditions besides those here discussed play a part in the control of the temperature gradient in the water at night.

This discussion has shown that the climate of Guiana, especially in the wet season, is less likely to produce complete deoxygenation of the swamps than that of the Paraguayan Chaco. The Guiana swamps were always highly deoxygenated and sometimes almost completely so. There can be little doubt that the Paraguayan swamps are still more deoxygenated than those of Guiana, and therefore that the results of the previous investigation, in spite of their large possible errors due to the inaccuracy of the methods employed, gave an accurate account of the condition of the Paraguayan swamps.

Swamps and other stagnant and shallow waters in the tropics differ in all the conditions which determine their oxygenation. It is certain that in other parts of the tropics swamps are to be found which are less deoxygenated than those of the Paraguayan Chaco and Guiana. The swamp examined by Bond (1933) seems to be a well-oxygenated tropical swamp, and the pool examined by Pruthi (1932) was also well oxygenated. A warm climate, absence of disturbance, low illumination, and active decay are the conditions which make for deoxygenation, and these conditions are characteristic of many types of tropical swamp, especially those with highly coloured water.

DISCUSSION.

The waters which we have been discussing have, when they are considered as a whole, very definite chemical peculiarities, which have been already defined (p. 164 ff.). Further, we have found that most of these peculiarities are developed in some of the forest waters in what is, for natural waters, an extreme degree. There are hardly any known natural waters which have so low a mineral content as that of the forest waters, except the waters of the Javan lakes examined by Ruttner—and the mineral content of these is probably low for the same reasons that that of the forest waters is low. The colour of the black waters is as dark as is ever found in the darkest natural waters, such as the pools and small lakes of heather moors. The pH is almost at the limit of acidity for natural waters ; it is, however, true that slightly greater acidity (pH 3·5–3·3) is sometimes found in the waters of heather moors and in some other natural waters.

On the other hand, the nutrient salts are present in the forest waters in quantities which are nearly normal for natural waters, although somewhat high. In the dry weather these salts may be present in unusually large amounts in the stagnant waters.

The black waters show most of these characters in a more marked degree than the white, but in the latter almost all the characters are developed to some extent. We will therefore consider the black waters as the typical forest waters and concentrate our attention upon them.

It will have been noticed that we have had to go to the temperate heath and moor waters to find the closest parallels to the forest waters in several respects. The forest waters resemble the moor waters in (1) their low mineral content, especially the very low calcium content, (2) their high acidity, resulting from the presence of free acid, (3) their dark colour, and (4), when they are stagnant, their low oxygenation. The only characteristic in which the forest waters differ from the moor waters is their relatively high content of nutrient salts, which are typically present in small amounts in moor waters.

The forest waters may therefore be described as being similar in chemical character to the moor waters except that they contain a much larger supply of nutrient salts. The resemblance is borne out by the nature of the flora and fauna of the forest waters. The moor waters are poor in animal and plant life, and we have seen that this is true of all the forest waters except the waters of the open swamps, where the high content of nutrient salts may be the cause of a larger development of fauna and flora. Rhizopoda are especially characteristic of moor waters and we have seen that they are also characteristic of the forest waters. Desmids are a group which occur in large numbers in some types of moor water, and we have found them prevalent in the swamps of Guiana (cf. van Oye, Javan shallow waters, 1922). It is possible that when the plankton has been examined in more detail, these resemblances may be extended.

Other features of the fauna and flora of the forest waters are clearly associated with the high content of nutrient salts. This is most obviously true of the blue-green algae, which are plentiful in the swamps in dry weather. The Copepoda and Cladocera of the forest waters are types characteristic of pools and ponds rather than of moor waters*.

When the cause of the resemblances between the forest and moor waters in chemical characteristics are considered, it is found that some, but not all, of the resemblances are due to similar conditions in the water and in its surroundings. Thus, the development of humic acids in the moor waters is due to decay, probably in more or less anaërobic conditions and in the absence of salts. Both these last two conditions are present in the Guiana swamps, and the production of acid in the water of the swamps may therefore be due to the the same causes as in the moor waters. Whether these conditions are also present in the waters at the source of the Wallaba streams, we cannot say. The dark colour is probably a direct result of the presence of humic acids in both types of water. The low oxygenation of the stagnant moor waters is due to stratification, to rapid removal of the oxygen by decay, and to slight photosynthesis owing to the poverty of the flora. In the Guiana swamps the same causes are at work, but the photosynthesis is slight owing primarily to the shading of the water rather than to the poverty of the flora, although the flora may also be poor. Where there is little flora, it is not, as in the moor waters, a result of the low content of nutrient salts but again, probably, of the

* I owe this fact to Mr. A. G. Lowndes of Marlborough College.

low illumination. Finally, the low mineral content of moor waters is due to their isolation from the subsoil by impervious layers. On the other hand, that of the Guiana waters is due partly to the poverty of the subsoil and partly to the heavy rainfall by which the forest is leached.

The absence of any large amount of free acid in the white waters of the Mixed and Mora forests is probably a result of the impermanence of these waters. The white-water streams are largely fed by rain flowing directly off the land. The only stagnant white waters are merely shallow pools on the ground and the water in them is continually replaced by fresh rain water. Wherever permanent stagnant water was found, even in these types of forest, it was highly coloured and acid (e.g. the Manicole swamp, which was in Mixed forest). All the most obvious differences between the white and black waters are results of the absence of free acids and colour in the former.

It seems therefore that the existence of more or less permanent swamps or pools is a necessary condition for the formation of waters of the black-water type except, perhaps, in the Wallaba forest, which was not investigated.

There is little to say of the waters of the streams and rivers. Their characters are all those which we should expect in waters derived from the forest waters, from which we know that they are derived. The small flora and fauna of these waters is probably mainly a result of the rapid currents, but the low illumination of much of the water in the rivers and streams may play some part in keeping the fauna and flora slight.

How far the waters of other tropical forest areas will be found to resemble these waters in Guiana is a question which it is difficult to answer at the present time. Some other forest waters are certainly dark (van Oye, Congo, 1926). A dark colour being associated in Guiana with stagnation of the water, it may, perhaps, be suggested that dark colour (and the concomitant acidity) is likely to be characteristic of forest waters where the slope of the land is slight and the water collects in swamps and does not run immediately into the rivers. Where there are no permanent stagnant waters, it seems probable that the forest waters will rather resemble the white waters of Guiana.

The low mineral content is probably characteristic of most forest waters, but it is not necessary that it should always be so low as in the Guiana waters, for it may depend partly on the geology of the country. The few data which are at present available agree with the conclusion that forest waters have low mineral contents. This is true of all the rivers of Guiana (salinities, 30–78 mg. per litre, Clarke, 1924) and of the Amazon and its tributaries (37–59 mg. per litre). A large percentage of the mineral contents of all these waters consists of carbonates. There seem to be no data of rivers in other forest countries. Where the low mineral content, high acidity, and dark colour are found together, the plankton is likely to bear resemblances to that of heather moors. It is noteworthy that van Oye found a plankton of this type both in the Congo (1926) and in shallow waters in Java (1922).

The succession of aquatic habitats as one passes inland from the rivers to the stagnant forest waters is marked by great chemical changes in the water. The most definite of these changes are :—

- (1) Increasing deoxygenation of the water.
- (2) Increasing quantity of carbon dioxide in the water.
- (3) Increasing acidity and colour.

Guiana is a country of considerable relief and the rivers are rapid. In a country of lower relief with slower rivers, some of the changes in the water as one passes up the rivers into the streams and swamps may be spread over a longer length of water, others over a shorter length, but there seems no reason to think that the changes would be different in kind from those which we have enumerated. In past geological periods forests of low relief were probably frequent, and differences of the types here set out must have been present between the waters of the rivers, streams, and swamps of these forests. Any aquatic animal migrating inland in such forests from the more or less normal surroundings of the rivers to the extreme conditions which we have seen to be characteristic of the stagnant waters must have passed this series of habitats. It is in the stagnant waters, and especially on their shore, that evolutionary change has been particularly active. It may be that the existence of this series of habitats, leading towards the shore of the stagnant waters enabled the migrating animal to become adapted to the conditions of the stagnant waters and so to reach the position where its further evolution occurred.

SUMMARY.

1. An account is given of the fresh waters of certain rain-forest areas in British Guiana.

2. The forest waters of this country are of two types :—

a. Black water, characteristic of swamps and of forest in which *Wallaba* (*Eperua* spp.) is dominant. Chemically this type of water is characterised by :—

1. Dark colour.
2. High acidity due to the presence of much free acid.
3. In stagnant waters, low oxygenation and high carbon dioxide content.

b. White water, characteristic of other types of forest, but never found in stagnant waters, which are always black. This water is without the dark colour and high acidity of the black water.

3. All the waters contain a very low mineral content and a moderately high content of phosphates, silicates, and nitrogen compounds.

4. The streams may contain black or white water, or water of intermediate type.

5. The rivers are rapid and completely disturbed. Their water is intermediate between the white and black waters. The black water loses most of its acidity and colour as it passes down the streams and rivers.

6. The changes in these waters which result from the seasonal variations in the rainfall were investigated.

7. The chemical characteristics of the waters resemble those of the waters of temperate moors. The resemblance is greatest in the stagnant black waters. The fauna and flora show resemblances to those of the moor waters but the forest waters also contain forms which are typical of waters with high organic content.

8. The absorption of light in these waters is rapid. Red light penetrates farther than light of other parts of the visible spectrum.

9. Diurnal variations in the oxygen and carbon dioxide contents of the stagnant waters occur, but are small, owing to the heavy shading of the waters.

10. The deoxygenation of the stagnant waters is great and sometimes complete in the lower layers of the water. It is greater in the dry season. The results confirmed the conclusion, founded on previous work on the swamps of the Paraguayan Chaco, that tropical shallow and stagnant waters are often deoxygenated. The stability of the stagnant waters is discussed and reasons are given for thinking that the climate of Guiana is less conducive to deoxygenation of these types of fresh water than the climate of the Paraguayan Chaco.

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EXPLANATION OF THE PLATES.

PLATE 1.

- Fig. 1. A view on the Cuyuni above the first falls, taken from the middle of the stream.
- Fig. 2. A small white-water stream in its more sluggish part near the river.

PLATE 2.

- Fig. 3. Karow Creek at the point at which the observations were made. This view may also be taken to be typical of the upper and more rapid parts of the forest streams.
- Fig. 4. The vegetation above the surface of a forest swamp. The swamp here illustrated is the Manicole swamp described in the text.

PLATE 3.

- Fig. 5. Vegetation in the grass swamp A.
- Fig. 6. A view of the pool B.



1.



2.

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RAIN-FOREST AREAS OF BRITISH GUIANA.



5.



6.

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APPENDIX I.—*Mineral contents and electrical conductivities of Guiana fresh waters.*

Mineral contents expressed in mg. per litre.

	Analysed in the laboratory of the Government chemist in London.								Analysed in Guiana.	
	Electrical conductivity. Reciprocal megohms per c.c.	Sodium. Na.	Potassium. K.	Calcium. Ca.	Magnesium. Mg.	Iron. Fe.	Aluminium. Al.	Sulphate. SO ₄ .	Silica. SiO ₂ .	Chlorides. Cl.
<i>Rivers.</i>										
1. R. Mazaruni at Mazaruni Station.	27.4	3.6	1.0	3.2	0.6	1.3	1.3	5.3	5.7	2.2
2. R. Cuyuni at Camp III.....	28.2	3.0	1.2	1.3	0.1	0.8	1.0	5.3	7.4	2.6
3. R. Demerara at Mackenzie.....	17.8	1.9	tr.	0.2	0.1	0.6	0.4	5.0	3.3	2.8
<i>Streams.</i>										
4. Karow Creek near Mazaruni Station.	24.3	3.3	0.7	1.2	0.3	0.8	0.2	3.0	6.5	4.2
5. Wallaba Creek near Camp III..	23.6	3.0	0.9	0.3	0.1	0.5	0.6	3.8	3.7	2.0
<i>Swamps, pools.</i>										
6. Grass swamp A near Mazaruni Station.	23.8	2.8	0.3	2.4	0.7	0.8	0.3	2.9	1.2	2.2
7. Swamp pool B near Mazaruni Station.	25.8	3.5	tr.	4.7	0.5	0.4	0.1	3.8	2.4	4.0
8. Manicole swamp near Camp III.	25.7	2.2	1.1	0.9	0.1	0.6	0.6	4.6	3.5	1.5
<i>British Waters.</i>										
Fulbourn, Cambs (hard) .....	..	19.2	..	107.7	3.4	..	..	32.8	..	28.6
Loch Katrine (soft)	50	3.2	..	1.9	0.9	..	..	5.4	tr.	4.8

No.	Source.	1.	2.	3.	4.	5.	6.	7.	8.	9.
		Date.	Time.	Tem- perature.		Tur- bidity.	Colour.	pH.	Dissolve Oxygen	
				Air.	Water.				c.c. per l.	Sat- ura- tion %
				° C.	° C.					
<i>Rivers.</i>		1933.								
1.	R. Mazaruni at Mazaruni Station, Surf...	7.5	8.30 a.m.	27.7	29.3	tr.	slight	6.75	4.42	2
2.	" " " Surf...	8.5	9.30 a.m.	28.2	29.7	tr.	"	6.7	4.51	1
3.	" " " 7 m. . .	8.5	9.30 a.m.	..	29.7	tr.	"	6.9	4.19	2
4.	" " " Surf...	10.5	2.30 p.m.	29.2	29.4	tr.	"	6.9 ?	4.42	2
5.	" " " 8.5 m. . .	10.5	2.30 p.m.	..	29.4	tr.	"	6.6	4.41	2
6.	" " " Surf...	25.5	9.0 a.m.	26.5	26.4	25	"	5.7	4.65	2
7.	" " " Surf...	29.5	10.0 a.m.	28.2	26.5	23	"	5.8	4.91	1
8.	" " " 7.5 m. . .	29.5	10.0 a.m.	..	26.4	23	"	5.7	4.65	2
9.	" " " Surf...	6.6	10.0 a.m.	24.3	26.5	55	"	6.4	4.85	1
10.	" " " 5.5 m. . .	6.6	10.0 a.m.	..	26.4	55	"	6.5	4.87	1
11.	" " " Surf...	16.6	1.0 p.m.	26.2	27.00	27	"	6.2	4.60	2
12.	" " " 8 m. . .	16.6	1.0 p.m.	..	26.96	27	"	6.1	4.69	1
13.	" " " Surf...	27.6	9.30 a.m.	25.6	26.6	36	"	6.4	4.06	3
14.	" " " Surf...	8.8	10.0 a.m.	25.8	26.8	20	"	6.45	..	3
15.	" " " 8.5 m. . .	8.8	10.0 a.m.	..	26.8	26	"	6.45	..	3
16.	R. Cuyuni just below first falls, Surf. . . .	30.5	10.30 a.m.	27.6	26.9	clear	"	6.25	5.04	1
17.	" " " 3.5 m. . . .	30.5	10.30 a.m.	..	26.9	"	"	6.25	5.27	1
18.	R. Cuyuni just above first falls, Surf. . . .	30.5	12.0 n.	28.5	27.1	"	"	5.8	4.48	2
19.	" " " 0.7 m. . . .	30.5	12.0 n.	..	27.1	"	"	5.8	4.59	2
20.	R. Cuyuni at Camp I, Surf.	9.7	9.0 a.m.	26.0	26.6	40	"	6.45	4.32	2
21.	" " " 6.5 m.	9.7	9.0 a.m.	..	26.6	43	"	6.45	4.00	3
22.	R. Cuyuni at Camp II, Surf.	18.7	9.0 a.m.	27.2	27.8	38	"	6.45	4.42	3
23.	R. Cuyuni at Camp III, Surf.	31.7	2.0 p.m.	27.8	27.9	37	"	6.3	4.82	3
24.	R. Demerara at Mackenzie, Surf.	25.8	9.0 a.m.	25.8	26.2	clear	moderate	5.4	3.41	4
25.	" " " 3.0 m.	25.8	9.0 a.m.	..	26.1	"	"	5.5	3.55	4
26.	River swamp near Camp I, Surf.	11.7	9.30 a.m.	..	..	28	slight	6.1	3.27	4
27.	" " " 0.6 m.	11.7	9.30 a.m.	..	..	..	..	5.9	3.10	4
<i>Streams: Black Water.</i>										
28.	Baracara Creek, R. Mazaruni	1.6	1.30 p.m.	..	..	clear	strong	4.6	4.70	
29.	Swamp stream near Karow Creek, Mazaruni Station.	18.6	11.0 a.m.	27.2	25.5	"	"	4.8	2.82	
30.	Second swamp stream near Karow Creek.	3.6	1.0 p.m.	..	..	"	"	4.35	1.78	
31.	Wallaba stream near Camp III, R. Cuyuni.	2.8	12.0 n.	..	..	"	moderate	4.25	4.73	
32.	Karakara Creek on R. Demerara near Mackenzie.	26.8	9.30 a.m.	27.1	24.2	"	strong	4.45	2.18	
33.	Another Creek on R. Demerara near Mackenzie.	29.8	10.0 a.m.	27.7	25.0	"	"	4.4	4.63	
<i>Streams: Intermediate.</i>										
34.	Karow Creek, Mazaruni Station	13.5	10.0 a.m.	..	..	clear	moderate	5.85	3.65	
35.	" " "	26.5	9.30 a.m.	24.7	24.3	"	"	5.7	3.47	

h waters made in Guiana.

11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
Other free acids.	Alkali Reserve.	Phos- phates.	Sili- cates.	Free Ammonia.	Nitrates.	Nitrites.	Organic Nitrogen.	Chlo- rides.	Remarks.
N/10 ⁻⁴ .	N/10 ⁻⁴ .	mg. PO ₄ per l.	mg. SiO ₄ per l.	mg. N per l.	mg. N per l.	mg. N per l.	mg. N per l.	mg. Cl per l.	
abs.	0.2	0.04	5.4	0.02	..	0.008	0.36	6	River very low.
abs.	0.16	0.05	3.3	0.04	..	0.004	..	4	River low.
abs.	0.16	0.04	4.0	0.05	..	0.004	0.20	4	" "
..	" "
..	" "
1.12	0.86	0.035	3.6	0.05	0.12	0.002	0.14	1.7	River much higher.
1.82	0.7	0.10	3.0	0.03	0.43	abs.	0.48	2	" " "
2.12	0.6	0.10	3.0	0.03	0.49	abs.	0.18	2	" " "
0.72	1.86	0.14	4.0	0.04	0.16	0.002	0.09	0.4	River flooded.
0.40	2.00	0.11	4.0	0.04	0.12	0.002	0.10	0.4	" "
1.16	0.76	0.085	6.0	0.05	0.085	0.002	0.47	1.8	River much lower.
1.56	0.60	0.075	5.2	0.04	0.075	0.002	0.44	1.6	" " "
1.08	1.30	0.04	5.6	0.055	0.04	0.003	0.16	1.0	River again higher.
abs.	0.92	0.09	4.4	0.02	0.16	abs.	0.12	1.8	River lower.
abs.	1.27	0.09	4.4	0.02	0.14	abs.	0.12	1.35	" "
1.2	1.04	0.035	4.0	abs.	0.29	0.001	0.11	4	River full.
1.32	1.08	..	..	..	..	..	..	..	" "
0.92	1.12	0.036	4.0	abs.	0.15	0.002	0.14	3	" "
0.88	1.14	..	..	..	..	..	..	..	" "
1.68	1.46	0.24	5.4	0.01	0.13	abs.	..	2.3	River very full.
1.60	1.38	0.24	5.2	abs.	0.13	abs.	..	2.4	" "
0.23	1.36	0.09	5.4	0.05	0.15	0.002	..	2.0	River less full.
0.16	1.20	0.20	6.0	0.04	0.045	0.003	..	2.0	River unchanged.
1.47	0.42	0.06	5.0	0.07	0.12	abs.	0.45	2.8	" "
1.39	0.36	..	..	..	..	..	..	..	" "
0.84	1.62	0.10	6.0	0.40	0.37	0.001	..	1.0	Stagnant water under trees and over mud.
1.04	1.66	..	..	..	..	..	..	..	" "
3.52	abs.	0.036	4.8	0.08	0.28	0.001	0.16	3.5	Rapid Wallaba stream.
2.88	0.64	0.015	6.4	0.22	0.17	abs.	0.27	2.1	Swamp water.
4.36	abs.	0.055	3.6	0.11	..	0.002	0.09	1.5	Swamp water.
0.74	abs.	0.10	3.6	tr.	0.14	0.003	..	2.0	Wallaba stream, after heavy rain.
2.61	abs.	0.11	6.9	0.09	0.23	abs.	0.32	2.9	Wallaba stream.
3.96	abs.	0.03	4.5	0.09	0.33	0.0035	0.21	3.2	" "
..	0.74	0.09	3.5	0.21	0.27	0.003	0.19	7	Creek very low.
1.68	1.24	0.10	6.2	0.14	..	0	0.31	3.5	Creek slightly higher.

APPENDIX II. (cont.).—Analyse

No.	Source.	1.	2.	3.	4.	5.	6.	7.	8.
		Date.	Time.	Tem- perature.		Tur- bidity.	Colour.	pH.	Disso- Oxy
				Air.	Water.				
				° C.	° C.				c.c. per l.	o
<i>Streams: Intermediate.</i>		1933.							
36.	Karow Creek, Mazaruni Station	5.6	10.30 a.m.	26.4	24.8	„	moderate	5.65	3.69
37.	„ „ „	17.6	10.0 a.m.	27.5	25.0	„	„	5.6	2.82
38.	„ „ „	29.6	10.0 a.m.	27.0	24.0	„	„	5.7	2.83
39.	„ „ „	10.8	9.30 a.m.	26.2	23.9	„	„	5.8	4.09
<i>Streams: White Water.</i>									
40.	Stream flowing into R. Cuyuni at Camaria.	30.5	1.0 p.m.	..	..	„	v. slight	5.95	2.57
41.	Forest Stream, ½ m. S. of Camaria Falls..	20.6	10.30 a.m.	25.8	23.7	tr.	„	6.3	3.66
42.	Oko Creek, Camp I	10.7	9.0 a.m.	..	..	clear	v. slight	6.7	3.36
43.	Tributary of Oko Creek	10.7	9.30 a.m.	..	..	„	none	6.1	5.31
44.	Creek ¼ m. E. of Camp II	18.7	10.0 a.m.	27.2	26.3	37	v. slight	6.1	4.28
45.	Creek 1½ m. W. of Camp II	21.7	10.0 a.m.	25.0	23.9	clear	none	7.0	5.84
46.	Head of small creek near Camp III, Surf.	28.7	10.0 a.m.	..	..	25	v. slight	5.3	1.58
47.	„ „ „ 0.2 m.	28.7	10.0 a.m.	..	..	25	„	5.25	1.68
48.	Akarabisi Creek, Camp III.	29.7	10.0 a.m.	..	..	tr.	„	6.45	5.44
49.	Pool at head of creek near Camp II, Surf.	20.7	9.0 a.m.	27.2	24.7	clear	v. slight	5.65	3.11
50.	„ „ „ 0.3 m.	20.7	9.0 a.m.	..	24.7	„	„	5.45	2.02
<i>Swamps and Pools.</i>									
51.	Grass Swamp A near Mazaruni Station, Surf.	11.5	9.30 a.m.	..	..	clear	strong	4.4	0.52
52.	Grass Swamp A near Mazaruni Station, 0.15 m.	11.5	9.30 a.m.	..	..	..	..	..	0.21
53.	Grass Swamp A near Mazaruni Station, Surf.	26.5	9.10 a.m.	24.7	25.4	clear	strong	4.45	0.78
54.	Grass Swamp A near Mazaruni Station, 0.38 m.	26.5	9.10 a.m.	..	25.5	„	„	4.35	0.46
55.	Grass Swamp A near Mazaruni Station, Surf.	1.6	10.0 a.m.	..	..	„	„	4.5	1.78
56.	Grass Swamp A near Mazaruni Station, 0.45 m.	1.6	10.0 a.m.	..	..	„	„	4.4	1.04
57.	Grass Swamp A near Mazaruni Station, Surf.	27.6	10.30 a.m.	28.5	25.2	„	„	4.45	2.30
58.	Grass Swamp A near Mazaruni Station, 0.45 m.	27.6	10.30 a.m.	..	25.7	„	„	4.4	0.90
59.	Grass Swamp A near Mazaruni Station, Surf.	29.6	10.30 a.m.	27.2	25.4	„	„	4.6	1.46
60.	Grass Swamp A near Mazaruni Station, Surf.	8.8	9.0 a.m.	27.5	25.7	„	„	4.45	0.15
61.	Grass Swamp A near Mazaruni Station, 0.30 m.	8.8	9.0 a.m.	..	25.6	„	„	4.4	0.00
62.	Another grass swamp near Mazaruni Station, Surf.	21.6	11.0 a.m.	28.8	25.4	„	„	4.45	1.32

h waters made in Guiana.

11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
Other free acids.	Alkali Reserve.	Phosphates.	Silicates.	Free Ammonia.	Nitrates.	Nitrites.	Organic Nitrogen.	Chlorides.	Remarks.
N/10 ⁻⁴ .	N/10 ⁻⁴ .	mg. PO ₄ per l.	mg. SiO ₄ per l.	mg. N per l.	mg. N per l.	mg. N per l.	mg. N per l.	mg. Cl per l.	
1.76	1.76	0.04	8.2	0.13	0.33	0.002	0.24	4.7	Creek unchanged.
1.29	0.64	0.015	6.4	0.29	0.17	0.001	0.50	2.9	Creek much higher.
2.22	0.84	0.10	5.8	0.04	0.08	0.001	0.10	3.5	Creek lower.
1.54	0.59	0.12	7.6	0.02	0.21	abs.	0.06	3.7	Creek again lower.
abs.	2.08	..	..	..	..	..	..	..	Slow current.
abs.	1.98	abs.	10.9	0.064	0.071	0.002	0.125	3.0	Rapid current.
abs.	1.88	0.18	9.0	0.18	0.19	0.001	..	4.5	Wide creek, slow current.
abs.	2.44	0.21	9.2	0.12	0.14	0.002	..	4.0	Small creek, rapid current.
0.17	1.32	0.09	6.2	0.13	0.14	0.002	..	2.5	Wide creek, slow current.
abs.	4.02	0.04	10.0	tr.	abs.	0.001	..	5.0	Very rapid current.
0.97	0.84	0.16	6.6	0.14	..	0.002	..	2.8	Stagnant pool.
1.23	0.70	..	..	..	..	..	..	..	" "
0.29	1.10	0.04	5.6	0.08	0.12	0.002	..	3.0	Wide creek, slow current.
0.7	1.00	0.17	6.6	0.10	0.02	0.002	..	4.3	Rapid current.
0.4	1.10	..	..	..	..	..	..	..	" "
..	abs.	0.08	3.7	0.36	..	0.001	1.0	2.0	Swamp very low. Stagnant.
..	..	..	..	..	..	..	..	..	Swamp very low. Stagnant.
4.44	abs.	0.10	3.0	0.24	abs.	abs.	0.16	4.0	Swamp slightly higher. Stagnant.
6.26	abs.	..	..	..	..	..	..	..	Swamp slightly higher. Stagnant.
4.50	abs.	0.04	3.6	0.17	0.09	0.001	0.16	1.5	Swamp slightly higher. Stagnant.
4.18	abs.	..	..	..	..	..	..	..	Swamp slightly higher. Stagnant.
4.30	abs.	0.01	3.6	0.06	0.07	0.001	0.17	2.5	Swamp unchanged. Stagnant.
4.70	abs.	..	..	..	..	..	..	..	Swamp unchanged. Stagnant.
4.90	abs.	0.15 ?	2.6	0.03	0.06	0.002	0.07	2.0	Stream through swamp.
1.92	abs.	0.04	2.8	0.17	0.10	tr.	0.60	1.3	Very much lower. Stagnant.
1.96	abs.	..	..	..	..	..	..	..	Very much lower. Stagnant.
5.04	abs.	0.006	3.0	0.075	0.08	0.003	0.12	1.1	After heavy rain.

APPENDIX II. (cont.).—*Analyses.*

No.	Source.	1.	2.	3.	4.	5.	6.	7.	8.
		Date.	Time.	Tem- perature.		Tur- bidity.	Colour.	pH.	Dissol Oxyg
				Air.	Water.				
				° C.	° C.				c.c. per l.
	<i>Swamps and Pools.</i>	1933.							
63.	Forest swamp near Mazaruni Station, Surf.	22.6	10.30 a.m.	27.3	24.7	„	„	5.0	0.52
64.	Manicole swamp near Camp III, Surf...	30.7	9.0 a.m.	..	..	„	„	4.35	0.41
65.	„ „ „ 0.38 m.	30.7	9.0 a.m.	..	..	„	„	4.25	0.34
66.	Swamp pool B, Mazaruni Station, Surf...	9.5	9.30 a.m.	..	..	clear	strong	4.2	0.54
67.	„ „ „ 0.38 m.	9.5	9.30 a.m.	..	..	„	„	..	0.46
68.	„ „ „ Surf...	27.5	11.0 a.m.	27.8	27.3	„	„	4.25	1.23
69.	„ „ „ 0.38 m.	27.5	11.0 a.m.	..	25.6	„	„	4.0	1.49
70.	„ „ „ Surf...	15.6	1.0 p.m.	..	..	„	„	4.25	1.34
71.	„ „ „ 0.45 m.	15.6	1.0 p.m.	..	..	„	„	3.9	1.34
72.	„ „ „ Surf...	27.6	11.0 a.m.	27.8	26.0	„	„	4.4	1.80
73.	„ „ „ 0.45 m.	27.6	11.0 a.m.	..	25.5	„	„	4.1	1.42
74.	„ „ „ Surf...	8.8	10.0 a.m.	27.5	27.3	„	„	4.05	0.86
75.	„ „ „ 0.45 m.	8.8	10.0 a.m.	..	25.7	„	„	3.95	0.53

h waters made in Guiana.

11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
Other free acids.	Alkali Reserve.	Phos-phates.	Sili-cates.	Free Ammonia.	Nitrates.	Nitrites.	Organic Nitrogen.	Chlo-rides.	Remarks.
N/10 ⁻⁴ .	N/10 ⁻⁴ .	mg. PO ₄ per l.	mg. SiO ₄ per l.	mg. N per l.	mg. N per l.	mg. N. per l.	mg. N per l.	mg. Cl per l.	
0.86	1.96	0.018	9.3	0.11	0.13	0.004	0.17	2.4	Very stagnant. Diluted by heavy rain.
3.22	abs.	0.53	4.0	0.13	0.103	0.0045	..	1.5	Stagnant. Forest shade.
3.56	abs.	..	..	..	..	..	..	..	Stagnant. Forest shade.
..	abs.	0.04	3.0	0.9	..	0.0035	0.45	11	Pool stagnant.
..	..	..	..	..	..	..	..	..	Stream across surface.
6.02	abs.	0.05	4.2	0.4	0.24	tr.	0.23	3.5	Stream across surface.
7.82	abs.	..	..	..	..	..	..	..	Stream across surface.
4.36	abs.	0.04	4.6	0.2	0.22	0.001	0.18	1.35	Stream across surface.
9.30	abs.	..	..	..	..	..	..	..	Stream across surface.
4.95	abs.	0.015	2.6	0.04	0.18	0.001	0.09	2.5	Stream strong. After rain.
9.10	abs.	..	..	..	..	..	..	..	Stream strong. After rain.
4.75	abs.	0.03	4.8	0.10	0.02	abs.	0.14	1.6	V. slight stream.
4.75	abs.	..	..	..	..	..	..	..	" "

Notes on *Argiope bruennichi* and other Pyrenean spiders. By MARY J. MARPLES, B.A. (Communicated by Dr. W. T. CALMAN, F.R.S., Pres. L.S.)

(PLATE 4)

[Read 10 January 1935]

THESE observations on Pyrenean spiders were made during a twelve-day visit to the Luchon Valley, Haute Garonne. This valley has a flat floor, about one and a half to two miles across, on either side of which the hills rise very steeply. They are mostly thickly wooded, with regions of cultivation at intervals. The floor of the valley is at an altitude of 600 metres, and is traversed by a tributary of the Garonne. It is for the most part cultivated, but there are a few marshy regions. Most of the spiders were obtained on the valley-floor, but some collecting was done at higher levels.

The most interesting form was *Argiope bruennichi* Scop., which was found abundantly near and in one of the marshes. There was a low bramble hedge and a large bed of rushes, and on these occurred a great number of webs. This spider was also found in the meadows and mowing grass fields of the lower slopes of the valley, but here the specimens did not seem to be either so large or so numerous as in the marsh.

A. bruennichi is a large spider, the female being about 18 mm. in body-length. The thorax is yellowish brown. The dorsal surface of the abdomen is yellow, with numerous narrow transverse black bands; the ventral surface is dark brown, with two broad longitudinal yellow stripes. The legs are conspicuously ringed with black. The male is much smaller than the female, its whole body-length being about 6 mm. The thorax is brown, and the abdomen is brown with small yellow marks on it. The legs are relatively long.

The web of the female is a most striking and interesting structure. It is an orb web, about 30 cm. in diameter, and placed vertically. In the centre there is a platform in the form of a loose network on which the spider rests head downwards. Above and below it in a vertical line there are in many cases zig-zags of a thick white silk ribbon. Each zig-zag is formed between two radials and is about 5 cm. in length. When the yellow and black spider is in the centre, between the two shining white zig-zags, the whole has a very striking and conspicuous appearance (Pl. 4, fig. 1). The spider takes up the characteristic *Argiope* position, with the two anterior legs on each side close together and pointing diagonally downwards, and the two posterior legs close together and pointing diagonally upwards, the whole forming a St. Andrew's cross.

The structure of the web varies in several ways. The numbers of spirals and

radii in seven different webs were counted. The spirals varied from 28 to 46, the radials from 30 to 46, except in a damaged web, which had 24. The web may have two zig-zags, one above and one below the platform, or only the one below, or the zig-zags may be absent altogether. The presence and absence of zig-zags was noted in a count of 90 webs. In 29 they were absent. Of the remaining 61 webs, 28 had zig-zags above the platform as well as below and 33 had only the lower zig-zag. No web having only an upper zig-zag was observed.

The arrangement of the zig-zags seems occasionally to be altered. One web was observed in which, in addition to the zig-zags above and below the platform, there was a third zig-zag placed vertically on one side (Pl. 4, fig. 2).

The central platform varied in structure. In some of the webs it consisted of a loose network, in which individual threads could be distinguished, while in others it was a closely woven sheet. Sometimes only the central sheet was present. In two cases females were observed sitting on a closely woven sheet, without a trace of the other parts of the web being there. In another instance a female was seen on a web consisting of the platform and just enough of the rest of the web to support two well-formed zig-zags. These do not seem to have been the remains of an ordinary web, much dilapidated, as no vestige of long radials could be found, and the sheets were attached to the surrounding foliage by short threads.

The web of the male seems to vary as much as, though in different ways from, that of the female. Two males were found each sitting in the centre of a perfect web, about 10 cm. in diameter and including a zig-zag above and below. That is, the web was an exact replica of that of the female, but very much reduced in size. Other males were found, owning only a central sheet, but the greatest number seemed to inhabit a tangle connected with the web of a female. This tangle was fairly large, but was loosely woven from few threads. It was not observed whether it was made by the male or the female.

It appears to be characteristic of the genus *Argiope* to decorate the web with zig-zags of thick silk ribbon. In 'A Naturalist in Guiana', Hingston describes the webs of several species of *Argiope*, all of which have a definite arrangement of zig-zags on the web. He says that they form a protective device and serve to draw away the eye from the spider sitting in the centre of the web. In 'Les Arachnides' Berland says that the presence of a zig-zag may possibly reinforce and strengthen the web. It does not seem credible that the zig-zag should be a protective device. It presents a most striking appearance, so that the web can be seen from a long distance away, and appears to direct the eye to the spider in the centre. It is possible that the enemies of *Argiope*, other than the human collector, are not affected in the same way, but the vivid colouring of the spider coupled with the shining ribbon of silk would appear to attract attention rather than evade it. On the other hand, there does not seem to be any reason why the web should need strengthening, particularly as so many webs are to be found without any zig-zags at all.

The food of *A. bruennichi* seems to consist chiefly of grasshoppers. The webs were all placed near to the ground, the central platform being usually about one foot up. The grasshoppers jump and are caught in the web. The subsequent behaviour of the spider was observed several times. The spider rushed down to its struggling prey, and proceeded to wrap it in a shroud of silk. The silk was sprayed out from the spinnerets in a wide ribbon. This passed to the end of one hind leg, and then across in a broad band to the other hind leg. The transversely stretched ribbon thus formed was flung over the prey by simultaneous movements of the hind legs. This checked the victim's struggles, and the spider then cut the threads that were holding it and turned it over and over until it was completely wrapped in silk. Finally, the spider bit the grasshopper, which might be left hanging from the threads of the web or carried to the centre, attached to the spinnerets. The poison did not seem to be very effective, for the grasshoppers struggled for a long time after they had been caught. There seems to be a tendency to leave the prey hanging in the web, and not to eat it until after dark. Several times a spider was observed in the centre of the web with several grasshoppers hanging in it, and the specimens kept in captivity tended to delay eating until night, even though they had been without food for several days.

Although grasshoppers formed the chief food, other things such as moths and various flies were eaten, but the same procedure was followed in their capture. When a very small fly entered a web the spider did not wrap it up, but merely carried it back to the centre and chewed it up straight away.

The breeding season was in progress when these observations were made, and it is possible that the tangles attached to the female's web are only present at this time. Frequently more than one male was found on such a tangle. In one case four males were observed on the tangle connected with the web of one female, the female being in the centre of her web.

Courting was not observed, although one male was seen on the actual web of the female, about 4 cm. away from her. Both remained absolutely motionless during the two hours in which they were under observation.

In one case, copulation was observed. A large female, which had just changed her skin, was hanging in the centre of the web upside down from the old skin, to which she was attached by a thread. Two males were present at first. One was pressed, head downwards, against the abdomen of the female with his palpal organ apparently inserted, while the other was lying on the first male's back. After a time the second male retired to the top of the web, while the first one remained in close contact with the female, with the palpal organ still inserted. They remained motionless in this position for about two hours. It seems likely that, as in many Epeirids, the male may be eaten by the female after copulation, as in one case the body of a male was found partially wrapped up in silk, hanging in the web of a female.

All the above observations were made on the spider in its natural surroundings, those which follow being made on spiders in captivity. Six living specimens,

three of each sex, were brought home to England. They were taken to Hampshire on 12 August 1933, having travelled from the Pyrenees in small boxes lined with grass. On 13 August, two females were placed separately in large glass tanks, with grass at the bottom and with twigs, while the third was placed late at night on a bush in the centre of a lawn. At about 9.30 p.m. one of the females in the tanks was seen to be walking about actively. On visiting her the next morning about 10 a.m. she was found to have made a large cocoon about 2.5 cm. in length. It consisted of a flagon-shaped vessel, hanging in a reticulate tangle (Pl. 4, fig. 3). The flagon was yellow, and had brown and reddish stripes passing from the neck and dying away on the swelling. The neck was closed by a yellow silk pad. Similarly, the female that had been liberated in the bush had made a cocoon, but in this case the spider had disappeared, and no trace of her was ever found. The first female lived for some days afterwards, spinning a complete web, though without zig-zags, and then suddenly disappeared.

The third female did not make a cocoon until 14 August. She had lost the right hind leg, so that the cocoon has not such a regular shape as the other two. She showed great activity during the evening of 14 August, so observations were made on her behaviour. Between 9.30 p.m. and 11.0 p.m. she laid down the beginning of a horizontal network, attaching the threads to a twig on one side and to the glass on the other. After that she remained motionless until 1 a.m. and then, as she began to wander away from the network, the observations were abandoned. On returning at 6.0 a.m. she was found to be completing the cocoon. The horizontal network had been very little increased, but from it was suspended a wide-necked, irregularly shaped cocoon, on which the spider was still putting the wrapping. She achieved this by crawling round the equator of the flagon, head downwards. The hind leg drew out the thread, not quite touching the spinnerets, but smoothing the thread on to the flagon. At intervals the abdomen was raised and the silk attached to the neck of the cocoon. This took place at about 1 min. intervals, but different amounts of silk were drawn out. On three occasions the number of movements of the hind leg between the attachments was counted. In one the silk was pulled out of the spinnerets 37 times before it was attached at the neck. In another only 16 pulls occurred, and in a third only 2.

The spinning was slow, and the spider rested frequently, remaining motionless in the inverted position. The silk was very fine, being invisible when drawn from the spinnerets.

By 6.40 a.m. the flagon was complete, and the spider proceeded to elaborate the horizontal network. The silk used for this part of the structure was much coarser than that used for the cocoon. It was white, and was clearly visible as it was being spun. The spider walked along the threads already present, drawing out the silk with her hind leg. She joined the silk wherever it crossed another thread and sprayed out a little rosette to attach the end of the thread to the glass and the twig. The thread was drawn out by a comparatively violent movement of the abdomen and was elastic, so that when it was attached

to the threads it contracted, and thus formed the reticulate network. The spider gradually worked her way downward, forming a network entirely surrounding the cocoon. Taut white threads were drawn out and attached to the glass, to other threads, and to the sides of the cocoon itself. The movements seemed to be entirely fortuitous, the spider moving in all directions, but the result was a fairly evenly placed, reticulate tangle, surrounding the cocoon.

The cocoons measured 19.8 to 22 mm. in length by 17 to 18.7 mm. in diameter, and the diameter at the mouth was from 7.2 to 11 mm.

One of the cocoons was opened, so that the internal structure could be studied (Pl. 4, fig. 4). The external covering was a very thin papery layer, and inside was an egg-case suspended in a loosely woven mass of floss. The egg-case was pale yellow in colour, more or less spherical in shape, but flattened above, where there is a sunken lid, similar to that which closes the cocoon. The diameter of the egg-case is 8 mm. and its depth 6.5 mm.

The egg-case is suspended from the neck of the flagon by threads attached to its own neck. It is surrounded by a mass of soft silk, which is reddish in colour above the egg-case and yellow beneath. Immediately above the egg-case there is an empty space, containing no silk—presumably for the escape of the young spiders.

On 23 March 1934, one of the cocoons was opened. The eggs were found to be rather shrivelled, probably owing to its having been kept in a too dry atmosphere. There were about 370 unhatched eggs and young spiders in the cocoon. One of the young spiders was alive, and many of the others apparently very recently dead. Another cocoon which was opened contained 286 eggs. The eggs are yellow and about 1 mm. in diameter.

The young ones had carried out their first moult and were conspicuously hairy. They were about 1.3 mm. long and very different in colour and proportions from the adults. The cephalothorax was pale yellow, with a faint grey band laterally over the bases of the palps and the first two pairs of legs. The bands of each side joined in the middle in such a way that a letter M was formed. The eyes were placed on conspicuous black spots. The anterior row was straight, the posterior row procurved. The posterior median eyes were the largest, touching one another, while the rest of the eyes were very close together. The anterior lateral eyes were very small. In the adult the eyes are relatively smaller and more widely separated, and the anterior median eyes are the largest. The breast-plate in the young was pale greyish, with thin dark borders, while in the adult it is black, with a broad white band down the middle. Dorsally the abdomen of the young was white in front, and posteriorly it had seven transverse grey bands, decreasing in size towards the anal tubercle. On boiling in potash, these bands were seen to be thickenings of the chitin, resembling the terga of segments. The sides of the abdomen had grey longitudinal markings, and there were transverse markings ventrally. The legs were pale yellow, with dark hairs, which were also present on the body. The legs were relatively much shorter than in the adult.

One immature male of another species of *Argiope* was obtained. It appears

to be *Argiope lobata* (Pallas), but, owing to the undeveloped condition of the palpal organ, it is impossible to be certain of the identification. This male closely resembled that of *A. bruennichi*, but its web differed somewhat. It consisted of a central sheet, surrounded by a small indefinite network. The central sheet was bounded by two zig-zags which met in a point at the top, and a second outer pair of zig-zags was placed in the network and joined in a point above the inner pair. The spider sat, head downwards, at the junction of the inner pair of zig-zags. Unfortunately, this type of web was only seen once, and a female was never obtained, so it is impossible to say whether it is typical of the species or an unusual arrangement.

Clubiona phragmitis C. Koch is another spider found in the same marsh as *Argiope*. It was not seen freely moving, but there were some complicated retreats found attached to the rush in the region of the flower. Each retreat consisted of two chambers. One of these was more or less spherical and completely enclosed, while the other attached to it was more elongated and had an opening at the lower end.

The walls of the chambers were made of tightly spun white silk. In the entirely enclosed chamber there was a female spider, while in the other there was a male. The two were so entirely unlike as to be taken for different families. The female was about 1.5 cm. long, a dark bottle-green in colour, with a rounded abdomen. The male was a brilliant reddish brown. It was somewhat shorter than the female, and had an elongated abdomen and very long legs. The jaws of the male were exceptionally large and formidable. In catching one of these the observer's thumb was bitten. The pain was violent, much greater than that of a nettle sting, and the place remained painful to the touch for nearly a week!

A certain amount of work was done on the number of spiders present in various parts of the Luchon valley. Counts were taken on the slopes of the mountains, in the coniferous forest region, the deciduous forest region, the meadows on the lowest slopes, and in the rushes of the floor of the valley.

The method used was to make ten sweeps through the herbage, using a net whose opening has a diameter of 30 cm. The sweeps were made as nearly 1 metre in length as possible, and care was taken to keep them equal in length. The spiders caught were placed in 70 per cent. alcohol and kept in separate labelled tubes. The type of trees was noted, and also the dominant herbs through which the sweeps were taken. The weather conditions were also noted. In each region the sweeps were taken twice.

The sweeps in the coniferous forest region were taken at an altitude of about 1280 metres on a hot, sunny, rather windy day. The trees were practically all *Picea excelsa*, and the herbs through which the sweeps were taken consisted chiefly of ferns, brambles, moss, wood-sorrel, and cranesbills, the sweeps passing chiefly through ferns. As will be seen from the table, very few spiders were obtained, and all belonged to the family Epeiridae.

The sweeps in the deciduous forest region were taken at a level just over

600 ms. on the lowest slopes of the Luchon valley. The day was very hot, but not sunny, and there was very little wind. The wood consisted of mixed deciduous trees, of which the most numerous were lime, sweet chestnut, sycamore, ash, and hazel. The herb stratum was chiefly composed of grass, cranesbills, violets, ivy, ferns, and bugles. These sweeps again did not yield a very large number of spiders (9 in each set of 10 sweeps), but though Epeirids form the majority, three other families were represented. Members of the Linyphiidae and Clubionidae were obtained in each set of sweeps, and one Thomisid occurred in the first set.

The meadow region was at about the same level as the deciduous forest region—that is, on the lowest slopes, but on the other side of the valley. The day was sunny and cloudless, very hot, but with a slight breeze. The meadow was on a fairly steep slope and was rather stony, the grass being somewhat thin. The herbs consisted of long mowing grass, scabious, small pinks, &c.

Table showing the numbers of spiders taken in two sets of ten sweeps in the different regions.

	Coniferous forest.		Deciduous forest.		Meadow.		Marsh.	
Epeiridae	6	5	5	5	14	11	37	75
Theridiidae	—	—	—	—	2	1	—	—
Linyphiidae	—	—	1	3	5	4	—	—
Thomisidae	—	—	1	—	10	1	1	—
Clubionidae	—	—	2	1	6	6	—	—
Sparassidae	—	—	—	—	2	1	—	—
Salticidae	—	—	—	—	5	7	—	—
Immature	—	—	—	—	8	1	—	—
Totals	6	5	9	9	52	32	38	75
	11		18		84		113	

The spiders were far more numerous in this region than in the forest, 52 spiders being obtained in the first 10 sweeps and 38 in the second. The larger number in the first set is due to the presence of a number of young unidentifiable specimens. A far larger number of families is represented too, though again the Epeirids appear most frequently. Fourteen were obtained in the first set of sweeps and eleven in the second, giving a total of thirty-five. Of these one specimen was a female and six were male *Argiope bruennichi*. Ten Thomisids, including one male, were obtained in the first set of sweeps, and only one in the second. The Clubionidae, Salticidae, and Linyphiidae occurred in about equal numbers, and one or two Sparassids and Theridions were obtained.

By far the greatest number of spiders were obtained from the sweeps in the rushes. These were taken from the marsh on the floor of the Luchon valley where the observations on *Argiope* were made. Although the spiders were

obtained in such large numbers, apart from one Thomisid, they consisted entirely of Epeirids. In the second set of sweeps seventy-five individuals were obtained. This very large number is due to the presence of quantities of young minute spiders. It is probable that these were the contents of a recently hatched cocoon. Four *Argiope* females were obtained in the first set of sweeps, but no males or females occurred in the second. Tetragnathidae were fairly common in that region, and seven specimens were found in each set of sweeps. Although these numbers only represent two samples of the spider population from each locality, they seem to show a difference in habitat of the various families. Far more spiders appear to live in open surroundings—that is, in meadow and marsh—than in the herbs of woodland regions. Epeirids occur most numerous in all regions. The meadow appears to provide an environment suitable for the greatest variety of families.

My thanks are due to Dr. Susan Finnegan for identifying the specimens of *Argiope bruennichi* and to my husband for help with the photographs.

REFERENCES.

- HINGSTON, R. W. G. A Naturalist in Guiana. London, 1932.
BERLAND, L. Les Arachnides. Paris, 1932.

EXPLANATION OF PLATE 4.

- Fig. 1. Female *Argiope bruennichi* in web with both zig-zags. $\times 2/3$.
Fig. 2. Male and female *A. bruennichi* in an unusual web with a lateral zig-zag in addition to the normal ones. $\times 2/3$.
Fig. 3. Cocoon of *A. bruennichi*. $\times 2/3$.
Fig. 4. Cocoon of *A. bruennichi* cut open to show the lid and the egg-case within, surrounded by a packing of soft silk. $\times 2$.



John Bale, Soria & Hargreaves, L^{td} Lander

ARGIOPE BRUENNICHI.

A collection of Bryozoa from South Africa. By CHAS. H. O'DONOGHUE, D.Sc., and DORA DE WATTEVILLE, Department of Zoology, University of Edinburgh. (Communicated by Dr. STANLEY KEMP, F.R.S., Sec. L.S.)

(PLATES 5 & 6)

[Read 10 January 1935]

INTRODUCTION.

The material here described was collected by Professor T. A. Stephenson of the University of Cape Town during the course of marine ecological investigations which he was carrying out in South Africa. We are indebted to him for the opportunity of examining it.

A description of a collection of Bryozoa from South Africa was published in 1924 (O'Donoghue, 1924), and in this was a review of the literature of the group for that region, with a list of all the forms recorded to that date. The total of 89 species and varieties therein given (p. 17) is not accurate, for, assuming all the species to be valid and making corrections for synonyms, the total is actually 140 species with 5 additional varieties.

Borg ('On the structure and development of *Heteropora*', 1932, pp. 258 & 307), suggests that the *Heteropora pelliculata* Waters, 1879, given in that paper may be *H. neozealanica* Busk, 1879, or a new species. Hastings (9, pp. 718, 719), further suggests that the form listed as *Cupularia umbellata* (Defrance, 1827), syn. *Discoporella umbellata*, possibly does not belong to that species, and, if not, it may prove to be new. Neither of these alterations, however, affects the total number of species.

Since that time the following references have been encountered, which increase the number, since none of them is included in the former paper :—

Elzerina blainvillii Lamouroux, as *Verrucularia dichotoma* v. Suhr, Ratisbon Flora, xvii. Jahrg. 1 Bd. p. 725, 1834, from Algoa Bay.

Beania (*Chaunosia*) *hirtissima* Busk, Quart. Journ. Micro. Sci. new series, vii. p. 241, 1867, from South Africa.

Farciminaria punctata Kirchenpauer, Cat. Mus. Godeffroy, p. 27, 1869, from South Africa.

Adeona intermedia Kirchenpauer, Journ. Mus. Godeffroy, p. 6, 1879, from Algoa Bay, South Africa.

Triticella boeckii G. O. Sars, Harmer, Polyzoa of the *Siboga* Exped. pt. 1, p. 91, 1915, from Algoa Bay.

Lastly, Hasenbank, in 'Bryozoa der Deutschen Tiefsee-Expedition,' 4 Teil, has recorded a number of forms from South Africa.

The following species have not been recorded previously from South Africa :—

Scruparia spiralis, sp. n. (p. 326), *Beania erecta* Waters (p. 342), *Carbasea macrocarpa*, sp. n. (p. 350), *Spiralaria denticulata* Busk var. *brevimandibulata*, nov. (p. 353), *Scrupocellaria maderensis* Busk (p. 356), and *Amastigia rudis* Busk (p. 361).

In the present collection the following species not previously recorded have been found :—

Lichenopora verrucaria (Fabricius), *Beania inermis* (Busk), *Rhyncozoon longirostre* (Hincks), and *Cellepora costazii* (Sav.-Aud.).

Also the following species are apparently new :—

Chaperia stephensoni, sp. n., *Beania paucispinosa*, sp. n., *Cribrilina simplex*, sp. n., *Rhyncozoon fulgidum*, sp. n., and *Holoporella capensis*, sp. n.

Adding in these records, the number of forms now known from South Africa amounts to 160 species with 5 additional varieties. The classification here adopted is that of Folke Borg (Bryozoa in 'Die Tierwelt Deutschlands,' 17 Teil, 1930).

Order STENOLAEMATA.

Division CALYPTROSTEGA.

Family LICHENOPORIDAE.

Genus LICHENOPORA (Defrance, 1825).

LICHENOPORA VERRUCARIA (Fabricius, 1780).

Lichenopora verrucaria Hincks, Br. Mar. Poly. 1880, p. 478, pl. lxiv. figs. 4 & 5 ;

Discoporella verrucaria Busk, Br. Mus. Cat. 1852, p. 31, pl. xxviii. figs. 2 & 3.

Localities.—Not previously reported from South Africa. Present specimens from Stil Bay, Cape Colony.

These specimens require no comment, as the form appears to be quite typical.

Order GYMNOLAEMATA.

Suborder CHEILOSTOMATA.

Section I. ANASCA.

Division I. MALACOSTEGA.

Family MEMBRANIPORIDAE.

Genus MEMBRANIPORA (Blainville, 1834).

MEMBRANIPORA MEMBRANACEA (Linné, 1758).

Flustra membranacea Linné, Syst. Nat. ed. 12, p. 1301 ; *Membranipora membranacea* Hincks, Br. Mar. Poly. 1880, p. 140, pl. xviii ; *Membranipora membranacea* Busk, Br. Mus. Cat. p. 56, pl. lxviii.

Localities.—Recorded previously from Muizenberg Beach (after storm), South Africa, by O'Donoghue, 1924 (18). Present specimens from St. James, Cape Colony.

MEMBRANIPORA GALEATA var. MULTIFIDA Busk.

Membranipora galeata Busk, Br. Mus. Cat. 1852, p. 62, pl. lxxv. fig. 5; *Chaperia multifida* Marcus, Sud Afric. Bry. aus der Samm. Gothenburgs Mus. 1922, p. 8, fig. 3.

Localities.—Previously reported from Simon's Bay, Cape of Good Hope, by Busk, in 1884 (5), and from Muizenberg Beach by O'Donoghue in 1924 (18). Present specimens from Seaforth, Cape Colony.

This species exhibits a fair range of variation in the relative size of the avicularia and spines, and also in the branching of the spines. Busk's description appears to need emphasising on two points:—Firstly, the enormous development of the lower multifid spines is a most striking feature—their branching may practically hide the entire surface of the colony. Secondly, the variation in the long, pedunculate, trumpet-shaped avicularia, rising below the aperture—these may be comparatively thin at the distal extremity, with a small triangular mandible or very broad distally, and bearing a spatulate mandible almost as long as the zooecium.

The present material has been compared with that reported previously from Muizenberg Beach, South Africa, by O'Donoghue, 1924 (18), and also with the type material in the British Museum. There seems to be no doubt that the three sets of specimens belong to the same variety. They are obviously similar to the material termed *Chaperia multifida*, figured by Marcus, 1922 (14), although complexity of structure makes it difficult to obtain a satisfactory drawing.

Genus STEGANOPORELLA.

STEGANOPORELLA MAGNILABRIS (Busk, 1852).

Membranipora magnilabris Busk, Br. Mus. Cat. p. 62, pl. lxxv. fig. 4; *Steganoporella magnilabris* Busk, Challenger Report, 1884, p. 75, pl. xxiii.

Localities.—Previously recorded from South Africa, Algoa Bay, by Busk, 1852. Present specimens from Stil Bay and Preekstoel, Cape Colony.

Genus CHAPERIA (Jullien, 1888).

CHAPERIA STEPHENSONI, sp. n.

Localities.—Present specimens from Stil Bay and Preekstoel, Cape Colony.

The zoarium is a closely encrusting form, of typical *Chaperia* type, and after preservation is of a red-brown colour, as are other members of the genus, e.g. *C. galeata* and *C. cristatum*. This colour disappears upon treatment with Eau-de-Javelle, but not on soaking in caustic potash. The whole surface is rough from the presence of numerous spines, projecting avicularia, and ooecia. The zooecia are regularly and quincuncially arranged.

The zooecium is roughly circular in outline, with an upstanding lateral wall; the front is partly calcified, partly membranous. The frontal membrane is more or less oval, the posterior margin is curved and entire, and the operculum occupies the upper portion of the frontal area. At the upper end of the zooecium,

above the aperture, are four spines, of which the two median are shorter and more slender than the two lateral. Arising from the median wall of the non-fertile zooecium between the bases of the median spines, is an elongated sessile avicularium with a sub-lanceolate mandible. This is directed forwards over the calcified frontal of the zooecium in front. Often a large trumpet-shaped avicularium arises from the calcified frontal of the non-fertile zooecium, and, when this is present, the sessile avicularium passes to one side of it. More frequently two such avicularia arise from the calcified frontal and then the sessile avicularium passes between them. These trumpet-shaped avicularia vary in size, but their forwardly-directed mandibles are always relatively shorter and broader than those of the sessile ones.

The ooecium is large, projecting, and visor-shaped, covering the anterior part of the calcified frontal of the zooecium. The margin of the ooecium is ridged, and on the ooecium above this ridge are borne two or three small, raised, chitinous areas. Where an ooecium is developed the sessile avicularium disappears, but the two (or the single) trumpet-shaped avicularia are carried up on to its anterior wall, and the smaller mesial pair of spines are pushed laterally to the sides of the base of the ooecium or apparently in some instances disappear.

The operculum is a shallow semi-circle in shape, with its curved anterior margin slightly thickened. The posterior margin is slightly concave. At the corner the marginal thickening is carried out into a quadrangular projection. The operculum of the fertile cell is fairly similar to that of the sterile cell, but apparently the anterior margin is slightly hooded and the antero-lateral corner of the quadrangular projection is carried backwards as a curved projection.

The present form in general appearance, colour, &c., bears some resemblance to *C. (Amphiblestrum) cristatum* (Busk, *Challenger* Report, 1884, p. 65) and to *C. (Membranipora) galeata* (Busk, *Challenger* Report, 1884, p. 64). From both of these it differs in (1) the spines in both are equal instead of markedly unequal; (2) Busk says that the ooecium bears a single large avicularium, which in *C. galeata*, according to the illustration, is sub-pedunculate, and in *C. cristatum* may be sessile or on a long trumpet-shaped peduncle—whereas in the material examined the ooecium usually has two, always at least one avicularium, neither sessile nor of the elongated type figured by Busk; (3) in both species, the ooecium bears no membranous areas, whereas they occur in the present form.

From *C. cristatum* the material here described differs in: (1) the former has anterior avicularia, which Busk describes as 'small, usually aborted'—in the latter they are always large and well developed; (2) in the former 'occasionally a long, trumpet-shaped, pedunculate avicularium springs from the front of the zooecium below the aperture', whereas in the latter there is always one, and usually two such avicularia present, and they are not of such a striking, elongated type. *C. galeata* apparently has no avicularia in this position.

The name *C. stephensoni* is suggested for the present species.

Division III. CELLULARINA.

Family SCRUPOCELLARIIDAE.

Genus *MENIPEA* (Lamouroux, 1812).*MENIPEA CIRRATA* (Solander).

Cellaria cirrata Solander, Zooph. 1786, p. 29, t. 4, f. D; *Menipea cirrata* Lamouroux, Hist. Polyp. corall. flex. 1876, p. 145; *Menipea cirrata* Busk, Br. Mus. Cat. 1852, p. 21, pl. xx, figs. 1, 2.

Localities.—Recorded previously from Simon's Bay, Cape of Good Hope, by Busk, 1884 (5). Also from Cape Infanta, Gordon's Bay, and Table Bay, Cape Colony, by O'Donoghue, 1924 (18). Present specimens from Seaforth, Cape Colony.

Genus *CELLULARIA* (Pallas, 1766).*CELLULARIA INFANTAE* O'Donoghue.

Cellularia infantae O'Donoghue, Report on the Bryozoa of the S.S. *Pickle* Collection, 1924, p. 30, pl. i, fig. 6.

Localities.—Recorded previously from Cape Infanta, South Africa, by O'Donoghue, 1934. Present specimens from Seaforth, Cape Colony.

CELLULARIA TRISERIATA Busk.

Menipea triseriata Busk, Br. Mus. Cat. 1852, p. 22, pl. xxiii. figs. 2, 3, 4; *Cellularia triseriata* O'Donoghue, S.S. *Pickle* Collection, 1924, p. 31.

Localities.—Recorded previously from South Africa by Busk, 1852 (2), and from Agulhas Light, Llandudno, Gordons Bay, S. Africa, by O'Donoghue, 1924 (18). Present specimens from Seaforth, Cape Colony.

Family BICELLARIELLIDAE.

Genus *BICELLARIA* (Blainville, 1830).*BICELLARIA CILIATA* (Linné, 1758).

Sertularia ciliata Linné, Syst. Nat. ed. 10, p. 815, 1758; *Bicellaria ciliata* Hincks, Br. Mar. Poly. 1880, p. 68, pl. viii; *Bicellaria ciliata* Busk, Br. Mus. Cat. ii. p. 41, pl. 34.

Localities.—Previously recorded from S. Africa by Hincks, 1880 (11). Present specimens from Seaforth, Cape Colony.

Hincks says 'in the S. African form the cells are much shorter than in the British; the portion below the joint is much less elongated, and the cells are therefore more closely packed together. The avicularium is of larger size and the inferior spine, so far as I have seen, is always more or less lateral. The habit also seems to be stiffer'.

Genus BUGULA (Oken, 1815).

BUGULA FLABELLATA (J. V. Thompson, 1868).

Acamarchis flabellata Busk, Br. Mus. Cat. 1852, p. 44, pls. li, lii; *Bugula flabellata* Hincks, Br. Mar. Poly. 1880, p. 80, pl. xi, figs. 1, 3.

Localities.—Recorded previously from S. Africa, Cape of Good Hope, by Hincks, 1880 (II). Present specimens from Cape Town pier.

Genus BEANIA (Johnston, 1847).

BEANIA INERMIS (Busk, 1852).

Diachoris inermis Busk, Br. Mus. Cat. 1852, p. 54, pl. 72; *Diachoris inermis* Busk, Challenger Report, 1884, p. 60.

Localities.—Not previously reported from S. Africa. Present specimens from Seaforth, Cape Colony.

The definition of the genus *Beania* (in conformation with the practice of many modern writers) has been slightly modified from that given by Hincks (II), in order to include the genus *Diachoris* of Busk (3). The sole valid distinction between the two being apparently that whereas in *Beania* originally the zooecia were joined by but one tube, in *Diachoris* they are joined by a number, often six. This seems hardly sufficient to merit the creation of a separate genus.

BEANIA PAUCISPINOSA, sp. n.

Present specimens from Seaforth, Cape Colony.

The zoarium is sub-erect and growing over colonies of *Menipea cirrata*, to which it adheres by rooting processes arising from the backs of the zooecia. Its colour, in specimens dried after preservation, is of an opaque glistening white. The moderately closely packed zooecia are joined together by tubes arising from their backs.

The individual zooecium is boat-shaped, the median walls are parallel, and the two ends equally rounded. The back of the zooecium is flattened and the sides almost vertical, but slightly curved. The whole of the frontal wall is covered by a thin, transparent, glistening membrane, as is usual in this genus. Eight curved spines arise from the margin of each lateral wall (in a single row) and curve mesially over the frontal wall; often they do not reach the middle line, but when they pass beyond this the amount of overlap is very small. The anterior marginal spine, situated level with the base of the operculum, is stouter, more upright, and has a blunter end than the others. Quite at the anterior end of the zooecium is a pair of somewhat shorter spines directed forwards and almost straight. The operculum is a deeper yellow than the rest of the frontal wall, semicircular in shape, with its posterior margin very slightly curved.

From the back of the zooecium, at its lateral margins, arise six tubes which join with the corresponding tubes from the adjacent zooecia. The usual arrangement is that a tube at the anterior end joins with the zooecium in front and

similarly the one at the posterior end unites with the one behind. Two tubes arise from the sides at equal distances from the ends and from each other. As the zooecia are generally alternate, the anterior lateral tube joins with the posterior lateral tube of a zooecium half in front and vice versa. Thus each zooecium is connected to six others.

While in general appearance the present form somewhat resembles *Beania pulchella* (Livingstone, 1929) (13), it does not belong to this group, members of which, like *B. hirtissima* (Busk) (4) and *B. columbiana* (O'Donoghue, 1923) (17), have a double series of marginal spines. Moreover, in *B. pulchella* the zooecia are generally in parallel and transverse rows, so that both the latero-dorsal tubes of one zooecium unite with the corresponding tubes in the neighbouring zooecium: thus each zooecium is connected to only four others instead of to six, as in the form here considered.

In some respects it also recalls *B. (Diachoris) inermis* (Busk) (2), as for example in the general shape of the zooecium and the compact manner of growth, in having a single row of marginal spines and no avicularia. However, the number, character, and arrangement of the marginal spines is quite different, and the method of interzooecial union is also different.

The present species seems to be undescribed, and is here regarded as new, and the name *B. paucispinosa* suggested.

Dr. Hastings directed our attention to an unnamed and unidentified specimen of *Beania* in the collection of the British Museum, which is similar to the present material. The differences are slight: all the spines are slightly longer and the lateral ones tend to overlap more, the anterior spines and the first pair of lateral spines are relatively stouter, and the lateral spines are generally nine in number. As the specimens agree in other respects, these minor divergences do not justify specific separation.

The British Museum specimen is from the *Discovery* Collection from St. W.S. 85, E. of Lively Island, E. Falkland Is. (25. iii. 27).

Division IV. CRIBRIMORPHA.

Family CRIBRILINIDAE (Hincks, 1880).

Genus CRIBRILINA (Gray, 1848).

CRIBRILINA SIMPLEX, sp. n.

Localities.—Present material from Stil Bay, Cape Colony.

The zoarium forms a conspicuous white glistening mass, closely adnate to the substratum—in the present material, stone or shell; and it may completely overgrow older encrusting colonies of other species—e.g. *Chaperia* sp. The flat zooecia are arranged in a radiating manner and, while the species in some respects recalls *Cribrilina philomela* var. *adnata* (Busk, 1884) (5) it presents an obvious difference in that the zooecia are not distant, but are closely packed, and the interzooecial sulci are quite narrow and bear no tubuli.

The zooecium is oval in general outline, and the aperture occupies about one-third of its length. The aperture is co-arcuate with curved posterior angles, much as in *Lepralia* (*Hippodiplosia*) *pallasiana* (Moll.). The posterior margin is straight and usually intact, but in some zooecia it has a small pointed notch in the middle line. The surface of the zooecium is well calcified and bears from six to eight lines of lacunae on each side, with or without a posterior median unpaired line. The lacunae are small, elongated, and about five in a line. The margin of the aperture is only very slightly raised.

Very occasionally the zooecia are abnormal. In one instance apparently two zooecia have run together and have but a single aperture; in another the zooecium is much reduced and is represented by only a few lines of pores with no aperture; in a third case the aperture is at the opposite end of the zooecium from those in the surrounding cells, and has been rotated through an angle of 90 degrees to the axis of the zooecium.

Careful examination of all the colonies in the collection, some of which are of a fair size, and presumably age also, failed to reveal any ooecia or avicularia. It is therefore not possible to give a description of the ooecium.

The operculum is rounded in shape, being more than a semicircle, and its border is strengthened by a thickened rim. At the base this rim bends outwards to form a rounded knob. The operculum has an outstanding rounded corner at the base and its posterior margin is slightly concave.

The form is distinctive and does not appear to agree with any previously described, so it is here considered as new and the name *Cribrilina simplex* suggested.

Section II. *ASCOPHORA*.

Family RETEPORIDAE Smitt, 1867.

Genus RETEPORA (Imperato, 1599).

RETEPORA TESSELLATA (Hincks, 1878).

Retepora tessellata Hincks, Ann. & Mag. Nat. Hist. 1878 (5), i. p. 358, pl. xix; Busk, Challenger Report, 1884, p. 112, pl. xxvii. fig. 8.

Localities.—Previously recorded from S. Africa, Simon's Bay, Cape of Good Hope by Busk. Present specimens from Sunday Point, Cape Colony.

This species was originally described by Hincks, 1878 (10), from South Australia, and again by MacGillivray, 1883 (15), from Australia. It was later recorded by Busk, 1884 (5), from Simon's Bay, Cape of Good Hope, and he recognized two varieties: (a) *R. caespitosa* resembling the type, and (b) *R. pubens* with a looser and more irregular habit of growth. The present material comprises only young colonies, and so its differences may be due to this. No ooecium was found. Hincks describes two spines on each zooecium, while Busk states that the young cells have four spines, of which only two (the lateral

ones) remain in the adult. Only two spines appear to be present in our specimens, although the colonies are young.

The avicularia, while being of the same type and having the same disposition as those described by Hincks and Busk, are not so numerous as they infer. These structures are subject to considerable variation, and it may well be that they would become more numerous as the colonies got older. In spite of these differences, there seems to be little doubt that all the material noted above is referable to this same rather characteristic species.

This species was made the type of a new genus—*Schizoretepora*—by Gregory, 1893 (8), on the grounds that the possession of a peristomial sinus was sufficient to merit this change. There does not seem to be a sufficiently well-marked distinction between sinuate *Retepora* and those with a closed labial pore to justify the creation of a new genus.

Canu and Bassler, 1917 (6), create yet another genus—*Schizellozoon*—with *Schizellozoon (Retepora) imperati* Busk, 1884 (5), as genotype; but it includes *Retepora tessellata*, and so is to be considered as a synonym of *Schizoretepora* (Gregory).

RETEPORA BILAMINATA Waters.

Retepora bilaminata Waters in Résultats du Voyage du S.Y. *Belgica*, 1904, p. 78, pl. vi, f. 8; *Retepora gilchristi* O'Donoghue, S. Af. S.S. Pickle Collection, 1924, p. 49, pl. iii, f. 19.

While not represented in the present collection, certain new information regarding this species has come to hand, and since it is a S. African *Retepora* it may be included here.

In a previous list (O'Donoghue, 1924) (18) a form of *Retepora* was described as new under the name of *R. gilchristi*. Sir Sidney Harmer suggested to us that it might be identical with the *Retepora bilaminata* of Waters (19). He kindly examined the material and this confirmed his opinion. Advantage was taken of a visit to the British Museum to compare the specimen with the type material of *R. bilaminata*, and there is no doubt that they are referable to the same species. Waters gives no description of his species, nor does he even mention it by name in the text of his paper. He merely says that 'a massive bilaminate species without any reticulation, occurring off S. Africa' was given him by Miss Jelly; he refers to an illustration and says he hopes to describe the species more fully later—this was never done. The illustrations are named *R. bilaminata*, so that the species must be regarded as established. The drawings, however, are not very satisfactory, and unless the type specimen were examined it would be difficult to refer other material to it.

The first description of the species, therefore, is that given in the previous S. African list (O'Donoghue, 1924) (18), and only a slight emendation to this appears necessary. In it five different types of avicularium are described, but it is perhaps doubtful whether the fifth of these is correctly described, their triangular appearance being probably due to their being seen obliquely.

Genus RHYNCOZON (Hincks, 1891). (Genotype, *Rhyncozoon*
(*Lepralia*) *bispinosa* Johnston, 1849.)

Rhyncopora Hincks, Br. Mar. Poly. p. 385, 1881. (Preoccupied : replaced by
Rhyncozoon in 1891.)

RHYNCOZON LONGIROSTRE (Hincks).

Rhyncopora longirostris Hincks, Ann. & Mag. Nat. Hist. (5) vol. viii. p. 125, 1881 ;
Mucronella tubulosa (Hincks), Waters, Ann. & Mag. Nat. Hist. (6) vol. iv. p. 19.

Localities.—Not previously recorded from S. Africa. Present specimens from Stil Bay.

This species was originally described by Hincks as *Rhyncopora longirostris* from Curtis Island, Bass Strait. He gave a description of the whole colony, but not of the chitinous parts. Dr. A. B. Hastings pointed out that the present material was like Hincks's, and so it was compared with the type material. Further, the chitinous parts were compared with a preparation of the chitinous parts made by Dr. Hastings from the type material. There seems to be no doubt that the present material is identical with Hincks's *Rhyncopora* (*Rhyncozoon*) *longirostris*.

Dr. Hastings figured the operculum and one of the smaller mandibles (9), but did not show one of the larger mandibles from which the species gets its name. Figures of all three are here provided, for comparison in the case of the first two and to illustrate the last.

RHYNCOZON FULGIDUM, sp. n.

Localities.—Present specimens from Stil Bay, Cape Colony.

The zooecium is closely adnate to the substratum. In the present specimens two of the colonies are growing upon shells and the others upon stones. They are all, in the dried condition, of a glistening white colour, and the largest colony is 37×25 mm. In the younger parts of the colony the surface is slightly roughened by the projections around the orifice, but in the older portions increased calcification has taken place, and the surface is fairly smooth, with the orifices perforating it. The zooecia are moderately regular and quincuncially arranged.

The zooecium at the growing edge of the colony is oval in outline, and has a smooth convex front. The orifice is semiorbiculate, with an emarginate lower border, the notch in it being quite wide. The upper border bears two to four slender spines, which are soon lost. Very soon a well-marked mucro arises from near the lower margin of the orifice, slightly to one side of the middle line, and this bears on its inner face a small triangular avicularium. At the same time as this is forming the frontal wall of the zooecium becomes thicker and granular in texture, instead of smooth. Several bluntly triangular spinous processes appear on the margin of the aperture, and a denticle develops within the lower margin, but this latter is masked by the mucro. A small mound which bears a triangular avicularium is sometimes produced on the lower part of the frontal wall. The mandible is borne at a slope to the surface of the

zoecium, and, while frequently it is in the same line as the zoecium, it may be transversely placed to it. The presence of this mound bearing an avicularium is quite irregular and some colonies appear to have none, while no colony has an avicularium on every zoecium.

The growth of these structures and the considerable thickening of the frontal wall of the zoecium causes the aperture to become sunk at the bottom of a well-marked tube. Thus the roughened stage is reached, but, as noted above, calcification continues until neither spines nor mucro project to any extent, and the tube from the aperture is quite deep. The margin of the zoecium bears a row of shallow depressions.

Ooecia are but sparsely developed in any of the colonies. Each is in the form of a low hemispherical chamber, practically buried in the frontal wall of the zoecium in front and showing only as a small bulge externally. The front wall of the ooecium is semicircular, flattened, and of a smooth, opaque, porcelain-like material which stands out in contrast with the more transparent calcification all round.

The operculum is almost a shallow semicircle in shape, with the posterior margin strongly convex: at each side of this margin is a deep notch. About half-way up each side of the operculum near the margin is a tiny circular perforation. On account of their rarity opercula of fertile cells were not examined.

The avicularia are apparently all of about the same size and shape; each is in the form of an isosceles triangle, with its apex turned over and with a slightly thickened base. The foramen is an elongated oval towards the base.

This form bears some resemblance to the genotype, *R. bispinosum* John., 1849, and to *R. verruculatum* Smitt, 1873. From the former it differs in the shape of the aperture, which has a much wider sinus in its posterior margin, in the absence of the large transverse avicularia, and in the presence of hinge notches on the operculum. Dr. Hastings informs us that in her preparations of the opercula of *R. bispinosum* there are no hinge notches. Furthermore, in Hincks's specimen of *R. bispinosum*, which we have been able to examine, the mucro is very much larger than in any of our material.

From *R. verruculatum* it differs in general appearance, in the distinctly smaller zoecia, and in not having such large, sharply-pointed avicularia—vide Hastings (9).

The present species appears to be undescribed, and the name *Rhyncozoon fulgidum* is here suggested.

Family ESCHARELLIDAE.

Genus SCHIZOPORELLA Hincks, 1880.

SCHIZOPORELLA CECILII (Audouin-Savigny).

Flustra cecilii Aud. Expl. p. 239; Savigny, Egypt, 1811, pl. viii, fig. 3. *Schizoporella cecilii* Hincks, Br. Mar. Poly. 1880, p. 269, pl. xliii, fig. 6.

Localities.—Previously recorded from South Africa, East Coast, Illora River, by O. Donoghue, 1924 (18). Present specimens from Stil Bay, Cape Colony.

SCHIZOPORELLA TENUIS Busk, 1884.

Schizoporella tenuis Busk, *Challenger* Report, 1884, p. 165, pl. 20, fig. 10.

Localities.—Previously recorded from South Africa, Simon's Bay, Cape of Good Hope, by Busk, 1884 (5). Present specimens from Stil Bay, Cape Colony.

The material agrees very well with Busk's description, except that whereas Busk gives, in his drawing, only one avicularium to each zooecium, here there are definitely two—one at each upper corner at the intersection of transverse and vertical interzooecial septa.

Family CELLEPORIDAE.

Genus CELLEPORA.

COSTAZIA COSTAZII (Savigny & Audouin, 1926) var. *ERECTA* O'Donoghue & O'Donoghue.

Cellepora costazii Savigny, Zool. Egypt, pl. vii, f. 4; Audouin, Explications, 1826.

Cellepora costazii Hincks, Br. Mar. Poly. p. 411, pl. lv. *Costazia costazii* Neviani, 1895.

Localities.—Not previously recorded from South Africa. Present specimens from Stil Bay, Cape Colony.

This species has not been recorded from South Africa previously, but it is very characteristic and there is little doubt about its identification. The material has been compared with that from the Vancouver Island Region, and it agrees closely with the variety described as *Costazia costazii* var. *erecta* O'Donoghue and O'Donoghue, 1923 (17), so called because of its branching upright habit.

The South African colonies are noticeably stouter than those from the Pacific Coast of North America—e.g. one of the colonies with a height of 25 mm. has a basal diameter of 9 mm. and a span between the branch tips of 25 mm. Another unbranched colony measures 32 mm. in height. Differences in growth-habit of this nature, while interesting, cannot be considered as significant in differentiating species.

The species *Costazia costazii* was first described by Audouin, 1826 (1), as *Cellepora costazii*. In 1895 Neviani (16) constituted a genus *Costazia*, of which this species became a type by tautonomy. Waters in 1899 (20) removed *Cellepora costazii* to *Lagenipora* (Hincks). Levinsen in 1909 (12) made a genus *Siniopelta*, and the first species he mentions under that genus is *C. costazii*, which is here designated the type of the genus. Neither of these authors seems to have noticed, however, that Neviani had previously made *Cellepora costazii* the type of a new genus (*Costazia costazii*), and consequently his generic name has precedence, as was pointed out by Canu and Bassler, 1920 (7).

Genus HOLOPORELLA (Waters, 1909).

HOLOPORELLA CAPENSIS, sp. n.

Localities.—Present specimens from Stil Bay, Cape Colony.

The zoarium is closely adnate to the sub-stratum, and in preserved dried specimens appears as a greyish-white uneven mass, with almost a 'pile' on the surface, due to projections and irregularities. It may extend over an area of several square inches. Often colony after colony will grow over pre-existing ones, so that in the end the mass may reach a thickness of 8–10 mm. Just at the growing edge of the colony the zooecia are little calcified and somewhat transparent, but all over the rest of the colony they are so heavily calcified and modified that their original shape is entirely lost. In the older parts the zooecia are irregularly arranged with their apertures facing in all directions; the peristome may be absent or strongly developed, and avicularia of different sizes are scattered vicariously and plentifully over the colony; so that it is not practicable to give a general description of its appearance.

Busk, 1884 (5), in describing *Cellepora tridenticulata* says 'another curious feature is the frequent occurrence on the surface of the zoarium of long tubular processes or tunnels, looking like enormously elongated zooecia. The nature of these appendages appears very obscure'. This description applies quite accurately to one of the specimens in the present collection. It is roughly an equilateral triangle in shape, with its sides about 30 mm. long, and all over the surface appear tubular processes, larger in diameter than the zooecia and projecting above them. The general calcareous material of the zoecium is continued on up to the lip of these tubes, so that they appear to be part of the colony. Fortunately, the surface of the colony is interrupted by a small barnacle, and upon the sides of this are two similar tubes which are obviously seen to belong to small tubicolous annelids. One of the tubes in the colony was carefully cleared of the adjacent zooecia, and was found to pass right through the living layer, through several dead layers, and on to the substratum below. The whole colony was removed from the piece of shell to which it was adherent, and then it was found that none of these tubes had any anatomical relationship with the colony, but were worm tubes on the shell. Obviously the worms had first colonized the shell and, later, the Bryozoon, and as layer after layer of the latter was laid down, the worms continued to add to their tubes, so as to keep them always just above the level of the zoarium. Without examination of the actual specimen it is impossible to say for certain whether this explanation applies to Busk's *Cellepora tridenticulata*, but his description suggests it as a possibility.

The individual zoecium at the growing edge of the colony is smooth and oval in shape, with a nearly semicircular aperture. (There is no sign of teeth on the margin of the aperture as in *C. tridenticulata*.) Each alternates with its neighbours on either side, and there is no ridge separating them, nor any marginal perforations along their edges. From the anterior edge arise two

fairly long, bluntly-pointed, tubular spines, but these are easily lost and have always entirely disappeared a short distance from the edge of the colony. As soon as the zooecium is formed a peristome is laid down around the aperture, and this develops in a varying degree. Very rarely in the older part of a colony a zooecium will be found with practically no peristome or with just a slight rim. Usually the peristome develops into a well-marked collar, and in the older regions this becomes deep enough to describe as a tube, and so the operculum may lie well below the peristomial margin. As this growth is proceeding the distal end of the zooecium turns up at right angles to the plane of the zoarium. The lower margin of the peristome is more developed than the upper, so that it protrudes as a lip-shaped rostrum. Generally also the projecting edge of the rostrum is thickened and carried on into a blunt tubercle, which, however, may be so developed as to constitute a distinct blunt spine. The peristomial portion, all that shows as a rule in the older portions of a colony, is perforated by irregularly-distributed, small, circular holes (which show clearly when the specimen is cleared with Eau-de-Javelle). As secondary growth takes place, the regular arrangement of the zooecia is entirely lost, so that finally the apertures point in different directions.

The operculum is a shallow semicircle in shape, with its posterior margin slightly convex. The anterior edge is strengthened by a thicker band, which bears a rough tubercle on its outer side about one-third of the way from the base, and at its base it is slightly swollen on the inner side.

Avicularia are developed quite near the growing edge and are, roughly, of two types—large and small; the large ones are borne upon oblique prominences, approximately conical in shape, but distinctly higher at the distal end. The small ones are almost flat on the wall of the zooecium. This division of avicularia is based upon the extremes, but actually there is so much variation in size that the two types practically grade into one another, there being, however, always a certain number markedly larger than the remainder. As the colony gets older the number of smaller avicularia increases, so that a great many are present. Both types of avicularia are produced without any regularity of arrangement or direction, and without any apparent definite relation to the zooecia, except that none of them are rostral avicularia.

The mandible is broadly spatulate, and has a thickened transverse bar across its base. Proximal to the bar is a thin curved sheet, with a slight notch in its margin on each side. Distal to the bar is a depression in the form of an isosceles triangle surrounded by a thickened margin, and near the apex of this again is an elliptical perforation covered by a very thin membrane.

This form is a *Holoporella*, but does not appear to agree with any described species, and is here regarded as new and the name *H. capensis* suggested.

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EXPLANATION OF THE PLATES.

PLATE 5.

- Fig. 1. *Chaperia stephensoni*, sp. n. A small portion of the zoarium, showing two ovicells. $\times 40$.
- Fig. 2. *Beania paucispinosa*, sp. n. Five zooecia. $\times 40$.
- Fig. 3. *Cribrilina simplex*, sp. n. Six zooecia. $\times 40$.
- Fig. 4. *Rhyncozoon fulgidum*, sp. n. A small portion of the zoarium near the growing edge, showing the spines and the shape of the primary aperture. $\times 66$.
- Fig. 5. *Rhyncozoon fulgidum*, sp. n. A small portion of an older region of the zoarium, showing an avicularium, the secondary aperture, and two ovicells. $\times 66$.
- Fig. 6. *Rhyncozoon longirostre*. Operculum. $\times 54$.
- Fig. 7. *Rhyncozoon longirostre*. Small avicularium. $\times 54$.
- Fig. 8. *Rhyncozoon longirostre*. Large avicularium. $\times 54$.

Nos. 6 and 7 are included for comparison with Hastings's figures (Cheilostomatous Bryozoa from the vicinity of the Panama Canal, 1929, pl. xiv) to show the identity of the species and also for comparison with no. 8, the characteristic avicularium for which the species is named, but which is not figured by Hastings.

Fig. 9. *Holoporella capensis*, sp. n. A small portion of the zoarium near the growing edge, showing the spines and the primary aperture. $\times 40$.

Fig. 10. *Holoporella capensis*, sp. n. A small portion of an older region of the zoarium, showing the development of avicularia and the secondary apertures. $\times 40$.

PLATE 6.

(All photomicrographs are at a magnification of 30 diams.
and are from untouched negatives.)

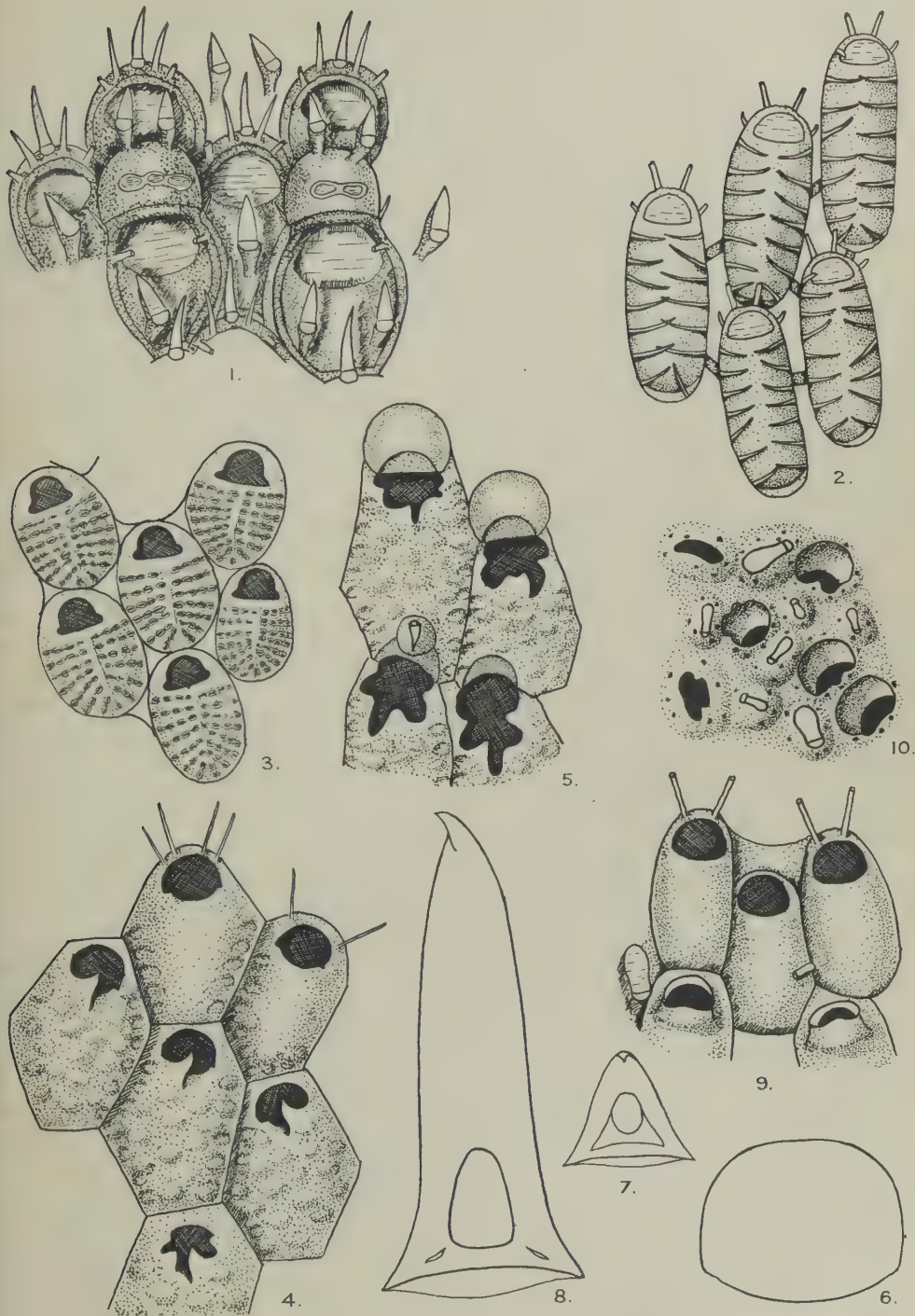
Fig. 11. *Chaperia stephensoni*, sp. n. The photograph shows two ovicells with their two avicularia; the sessile avicularia show near the lower margin; near the upper margin a calcareous worm tube breaks the surface of the colony.

Fig. 12. *Beania paucispinosa*, sp. n. A small portion of the colony.

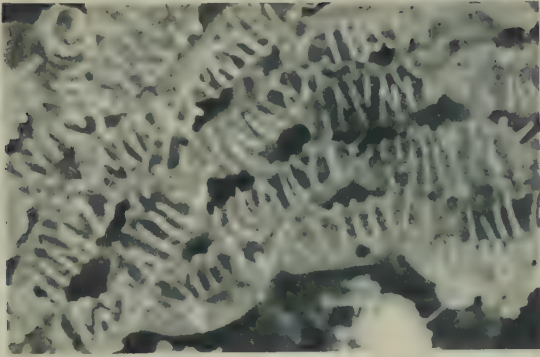
Fig. 13. *Oribilina simplex*, sp. n. A small portion of the colony. In the lower right-hand quarter are two distorted zooecia such as are met with occasionally in this species.

Fig. 14. *Rhyncozoon fulgidum*, sp. n. Towards the upper margin are several young zooecia with their spines, and at the lower margin older zooecia with secondary orifices.

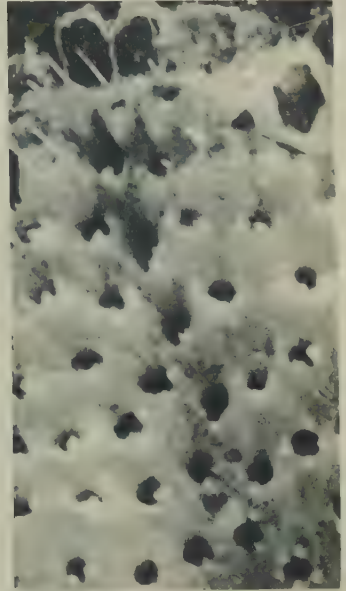
Fig. 15. *Holoporella capensis*, sp. n. A small portion of the colony cleared with Eau de Javelle. It shows the irregular and jumbled arrangement of the secondary zooecial apertures and the avicularia. The mandibles of the latter have been removed in clearing.



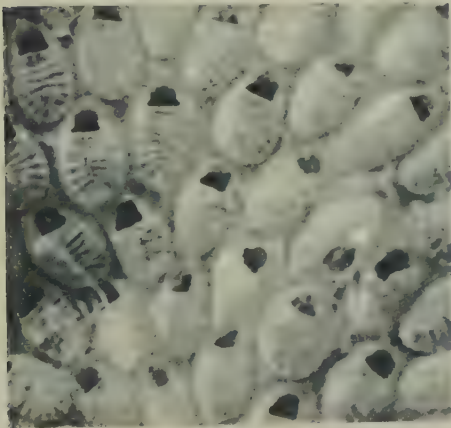
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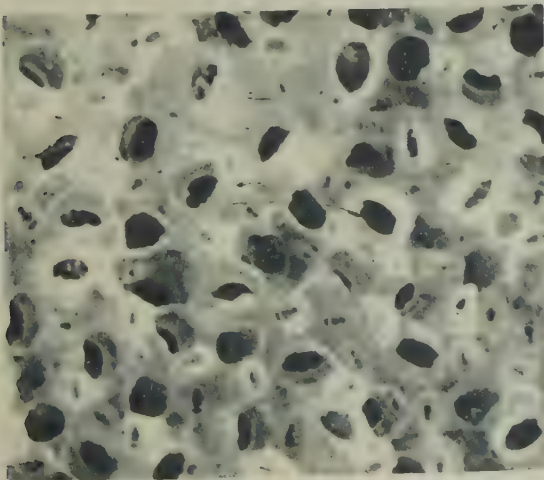
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John Ben Sans & Tinsleyson, Ltd London

Reports of the Cambridge Expedition to British Guiana, 1933. Respiratory adaptations of the fishes of the forest waters, with descriptions of the accessory respiratory organs of *Electrophorus electricus* (Linn.) (= *Gymnotus electricus* auctt.) and *Plecostomus plecostomus* (Linn.)*. By G. S. CARTER, M.A., Ph.D., F.L.S.

(With 9 Text-figures)

[Read 24 January 1935]

THE fishes which are to be discussed in this paper came from waters of various types in the districts of Guiana that were visited by the expedition. In a previous paper (Carter, 1934) the area in which these observations were made has been defined, and an account of the chemical characteristics of the waters has been given. Willmer (1934) has published a paper in which the condition of the blood in several fishes from these waters has been discussed.

Before we can discuss the oecology of the fauna of these waters we must have before us some general conception of the conditions in the different environments from which they came. This has been provided by the previous paper, but it will be convenient to summarize here the results that are of most importance from the point of view of the oecology of the fishes.

The forest waters fall into three categories—the waters of the forest swamps, those of the streams which drain the forests and those of the larger rivers. The streams drain not only the swamps but also large areas of the forest where the greater slope of the ground prevents the formation of swamps. The streams are of two distinct types—the black- and white-water streams—and the water differs greatly in some of its chemical characters in the streams of these two types, but I have no observations that would correlate these differences with the distribution of the fishes. We therefore need not distinguish these types of stream for the purposes of this paper.

The environmental differences in these waters that are most clearly of importance in the oecology of the fishes are those in their gas contents. Comparative values of these characters for the various waters are given in the following table. In the rivers and swamps the conditions show considerable variation with the seasonal differences in the rainfall. We must therefore distinguish between their dry- and wet-weather conditions. The seasonal

* The author is indebted to Mr. J. R. Norman of the British Museum for the identification of all the fishes mentioned in this paper.

changes in the streams were less accurately determined and are probably less important :—

Average conditions in the various environments.

	Season.	Current.	pH.	Dissolved oxygen.		Free carbon
				c.c. per litre.	Percentage saturation.	dioxide. c.c per litre.
Rivers.....	Dry.	Strong.	6.7	4.4	80	1.1
	Wet.	V. strong.	6.1	4.7	80	2.2
	Flooded.	„	5.85	4.85	83	7.3
Streams .....	....	Strong.	4.2-7.0	3.5	60	5.4
Swamps	Dry.	Stagnant.	4.4	0.4	7	10.5
	Wet.	Often flowing.	4.3	1.3	21	7.1

The figures given in this table are averages obtained from all the observations made in water of each type. They must not be taken as giving more than rough indications of the conditions likely to be found in the various waters. It must also be pointed out that some of these averages were made from determinations which had large ranges of variation. This is true, for instance, of the pH of the stream water, which varied greatly with the type of the stream from which the water was taken; and of the oxygen content of the swamp water, in which the variations were associated with the weather and with the position of the water in the swamp—whether the sample was taken from a stagnant or a flowing pool, from the surface or the lower layers of the water, and so on. It is also important to remember that the figures of this table give no idea of the extreme conditions in some of the environments. The lower layers of the swamp water were often almost completely deoxygenated, and the surface water (at a depth of 1/2 inch) occasionally so. Even in the wet season, the surface water of the swamp very rarely contained as much as 2.5 c.c. of oxygen per litre (40 per cent. saturation), and this maximum of aëration for swamp water was only observed in pools through which there was a strong current, or after heavy rain.

It is only in the swamps that the conditions of the environment would appear to be of such a kind that fishes would have any difficulty in maintaining their life without considerable adaptation. Examination of the fish fauna confirmed this conclusion.

In each of the three categories of forest waters the fishes are distinct. Both the larger rivers and the forest streams contain very large and diverse faunas of fishes, but most of the fishes of the streams are different from those of the rivers. The swamps almost always contain fish but their fauna is much more restricted.

By far the majority of the fishes of the rivers and streams do not breathe air and possess no abnormal adaptations in their gills. Thus, the conclusion that these environments provide conditions in which it is possible for an animal with a normal respiratory system to live is confirmed by observation of the

fishes. In spite of this, Willmer (1934) has shown that physiological adaptation is present in the fishes of the rivers and streams. The bloods of these fishes differ in some of their characters and these differences are correlated with the conditions of the habitats.

The two air-breathing species with which we shall be concerned in this paper, the electric eel and *Plecostomus plecostomus* are exceptional in living (in these parts of Guiana) mainly in streams and yet possessing organs of aërial respiration. They live chiefly in muddy pools in the beds of the streams, and their habit of breathing air is probably associated with the muddiness (and consequent greater deoxygenation) of their habitat.

Fish of numerous species from all the forest waters were collected by us for the Indians. In order that as many as possible might be alive when we received them, we arranged that any fish that was to be brought to us should be placed in water immediately after it was caught and that it should be brought to our laboratory as quickly as possible. We found that very few of the river fish were brought in alive: they were unable to live in the small vessels into which they were put by the fishermen. On the other hand, most of the fishes from the streams were alive when they were brought to us. Thus, Willmer's conclusion that the condition of the blood in the river fish should result in their being more sensitive to unfavourable respiratory conditions was confirmed, and was found to be true of many species besides those which he investigated.

We kept fish of several species from the streams in small vessels in the laboratory until they showed obvious signs of exhaustion and were clearly near death. The oxygen and carbon dioxide contents of the water in which they had been living were then estimated, in the hope that some idea might be obtained of the sensitivity of the various species to these unfavourable conditions. Such experiments are clearly inexact: the fish may die from other causes besides the poor aëration of the water, and conditions in which a fish is distressed are not necessarily close to those in which it can live permanently. But a series of experiments of this type give some idea of the relative sensitivity of the different species.

We found not much variation in the sensitivity of the fish from the streams. Many species were on the point of death in water which contained between 0.5 and 1.0 c.c. of dissolved oxygen per litre, and several species were found to be able to live normally and apparently undistressed in water which contained 1.5 c.c. per litre. The free carbon dioxide content of water in which these fish were distressed was much more variable, its values lying between 5 and 20 c.c. per litre. These conditions are very much less favourable than those which were found by analysis to be present in the water of the streams.

In most of the swamps small Characinids and other small fishes (*Pyrrhulina filamentosa* C. & V., *Lebistes reticulatus* (Peters), *Hemigrammus unilineatus* (Gill), &c.) are common. Small specimens of *Hoplias malabaricus** (Bloch.)

* Native name 'Houri'.

are also common in the swamps, and some species of *Aequidens* (especially *A. potaroensis* * Eigen. and *A. tetramerus* † (Heckel)) are frequent. Species of *Crenicichla* (especially *C. lugubris* ‡ (Heckel) and *C. alta* Eigen.) are occasionally found in the swamps. Some of the fishes of the streams invade the swamps in the wet season.

Apart from these, the only common fishes which are true inhabitants of the swamps are the air-breathing forms. *Erythrinus erythrinus* § (Schn.) and *Hoplerythrinus unitaeniatus* || (Spix) are common in all the swamps. *Hoplosternum littorale* ¶ occurs in the swamps but is much more typical of the stagnant drains and ditches of cultivated land, where it is extremely common.

The swamp fauna includes some other fishes, but we found no others which were common enough to be described as important members of the fauna.

The fauna of fishes in these swamps of the Guiana forest is thus very similar to the fauna of the Paraguayan swamps, which was investigated during a previous expedition (Carter & Beadle, 1931). Many of the fishes which have been mentioned as occurring commonly in the Guiana swamps are either present in the Paraguayan swamps or are represented in them by closely related species.

Experiments were carried out on the sensitivity of some of the common swamp fishes to unfavourable respiratory conditions. Several specimens of one of the small Characinids, *Pyrhulina filamentosa*, were kept in the laboratory in vessels in which they were prevented from reaching the surface of the water. They died after two hours, and the water was then found to contain 1.3–1.5 c.c. of dissolved oxygen and 5–18 c.c. of free carbon dioxide per litre. Thus, these fishes were no less sensitive to deoxygenation of the water than the fishes of the streams which had been investigated in the experiments reported above. The conditions in the main body of the water of the swamps are often far less favourable for the respiration of the fish than the conditions in which these fishes were distressed, and it is clear that, in order to maintain their life, the fish must have some other means of providing for their respiration. There can be no doubt that the means they employ for this purpose is to make use of the thin surface film, which must be more highly oxygenated than the rest of the water. When the swamp water is strongly deoxygenated, these fishes can be seen to come to the surface and to pass water from the surface film over their gills, but they never break the surface and take in air. The results of the experiments and of the analyses of the swamp water show that small fishes such as these can in this way obtain water which contains at least 1 c.c. more dissolved oxygen per litre than the main body of the water in which they are living.

The other swamp fishes which do not breathe air, although some of them may reach a length of 8–10 inches, use the same method of maintaining their respiration in the swamp water. Similar habits were observed in several of the fishes of the Paraguayan swamps.

* Native name 'Sebalieh'.

† Native name 'Patwa'.

‡ Native name 'Lukanani'.

§ Native name 'Waraba'.

|| Native name 'Yarow'.

¶ Native name 'Hassa'.

The air-breathing fishes were found to be able to live in the laboratory in almost completely deoxygenated water. They lived for several days in very small quantities of water in shallow dishes and tanks.

ACCESSORY RESPIRATORY ORGANS.

Family ELECTROPHORIDÆ.

ELECTROPHORUS ELECTRICUS (Linn.).

The electric eel has attracted attention for more than one peculiarity of its structure in addition to the electric organs of its tail. In spite of this, the accessory respiratory organs that are present in its mouth have been comparatively little studied. An account of their arrangement and of some of the details of their structure was recently given by Evans (1929), who discusses the earlier literature.

The accessory respiratory organs consist of a vascular epithelium which occupies almost the whole of the upper and lower surfaces of the mouth and

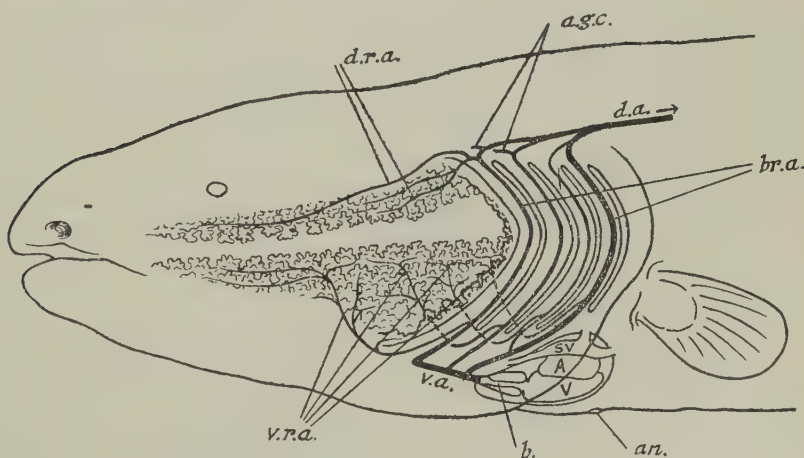


FIG. 1.—A diagrammatic lateral view of the arterial supply of the accessory respiratory organs of *Electrophorus electricus*.

A, auricle; an., anus; a.g.c., artery to the wall of the gill chamber; b., bulbus; br.a., branchial arches; d.a., dorsal aorta; d.r.a., dorsal respiratory artery; s.v., sinus venosus; V., ventricle; v.a., ventral aorta; v.r.a., ventral respiratory artery.

extends on to the inner surfaces of the gill bars, and on to the dorsal parts of the lateral wall of the gill chamber (fig. 1, and Evans, 1929). Wherever the vascular epithelium occurs, it is raised on branching, papillated prominences. In the mouth these prominences are arranged in longitudinal rows which fit together, when the mouth is partly closed, so as to leave only narrow passages between them (fig. 3).

When the fish is living in poorly oxygenated water, it frequently visits the surface and takes in air at the mouth. The air is allowed to escape at the

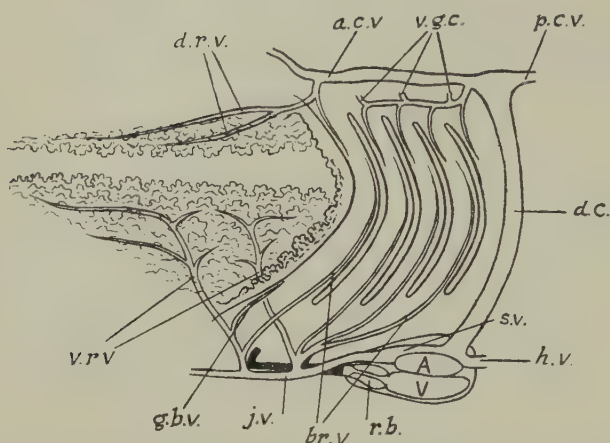


FIG. 2.—A diagrammatic lateral view of the venous supply of the accessory respiratory organs of *Electrophorus electricus*.

A., auricle; *a.c.v.*, anterior cardinal vein; *br.v.*, branchial veins; *d.c.*, ductus Cuvieri; *d.r.v.*, dorsal respiratory veins; *g.b.v.*, veins from prominences of the gill bars; *h.v.*, hepatic veins; *j.v.*, jugular vein; *p.c.v.*, posterior cardinal vein; *r.b.*, ridges of the bulbus; *s.v.*, sinus venosus; *V.*, ventricle; *v.g.c.*, veins from wall of the gill chamber; *v.r.v.*, ventral respiratory veins.

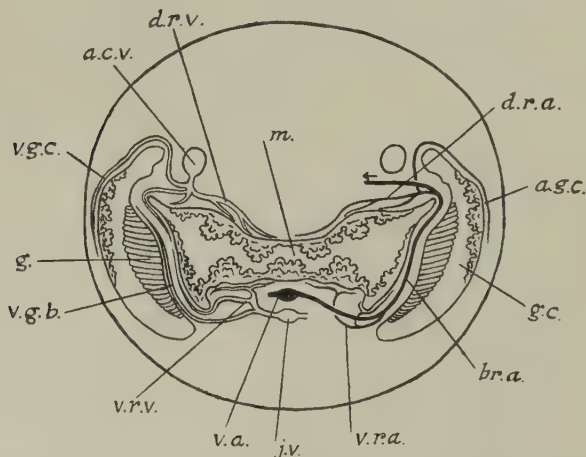


FIG. 3.—A diagrammatic transverse section through the head of *Electrophorus electricus* at the level of the first gill bar. Arterial supply of the accessory respiratory organs on the right, venous supply on the left. Lettering as on figs. 1 & 2, and :

g., gills; *m.*, mouth; *g.c.*, gill chamber; *v.g.b.*, branchial veins.

opening of the gill chamber. There can be no doubt that it is used in the mouth and the gill chamber to aërate the vascular epithelium of accessory respiratory organs. I have no observations on the behaviour of the fish in well oxygenated water, but its normal habitat in Guiana—muddy pools in the streams—makes it probable that air-breathing is its habitual method of respiration in the not very well oxygenated water of these pools.

HISTOLOGY OF THE GILL FILAMENTS AND ACCESSORY RESPIRATORY ORGANS.

The gill filaments of this fish are poorly developed (fig. 4). The secondary folds (*s.f.*) are narrow and thick, their breadth being only about four times their thickness. Their condition may be compared with that of the secondary folds in *Plecostomus plecostomus* (fig. 6, p. 229), where the folds are well developed

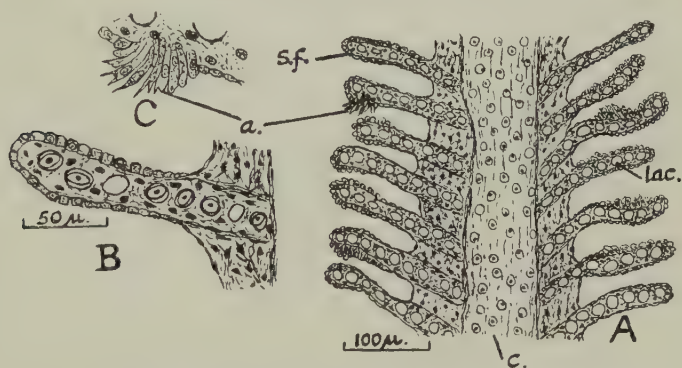


FIG. 4.—Longitudinal sections of the gill filaments of *Electrophorus electricus*.

A. A section of the whole filament; B, C. Enlargements of part of A.
a., amoeboid epithelium cells; *c.*, supporting tissues; *lac.*, lacunae of the secondary folds; *s.f.*, secondary folds.

but not abnormally so for a fish from a tropical swamp. In *Electrophorus*, the epithelium over the folds is much thicker than in normal teleostean fishes. It is almost cubical in places. Some of the cells of this epithelium (fig. 4, *a*) appear—in the preserved material which is all that I have been able to examine—to be amoeboid with processes stretching out from the surface of the fold. The meaning of this peculiarity is not apparent.

It is noteworthy that the condition of the secondary folds in *Electrophorus* greatly resembles their condition in *Hoplosternum littorale*, a fish which was shown in the previous paper (Carter & Beadle, 1931) to be unable to live by the respiration of its gills even in well oxygenated water. In the gills of *Hoplosternum* the secondary folds are as thick and shallow as those of *Electrophorus*, and the epithelium over the folds is thick and almost cubical. These resemblances between the gills of *Electrophorus* and *Hoplosternum* make it very improbable that the gills of the former are efficient organs of aquatic respiration,

A section through a small part of the vascular epithelium of one of the prominences of the accessory respiratory organ of *Electrophorus* is shown in fig. 5. It will be seen that the epithelium (*r.ep.*) is very vascular and that there is a large supply of blood vessels (*b.v.*) in the tissues below the epithelium. The whole of the prominences are covered by this epithelium.

Evans (1929) described an alveolar tissue, resembling the tissue of a mammalian lung, which he found lying on the outer surface of the prominences and apparently mainly in the spaces between them. This would be an important observation, for a respiratory epithelium of such a type would be very unusual in the accessory respiratory organ of a fish, almost all of which are covered by typical

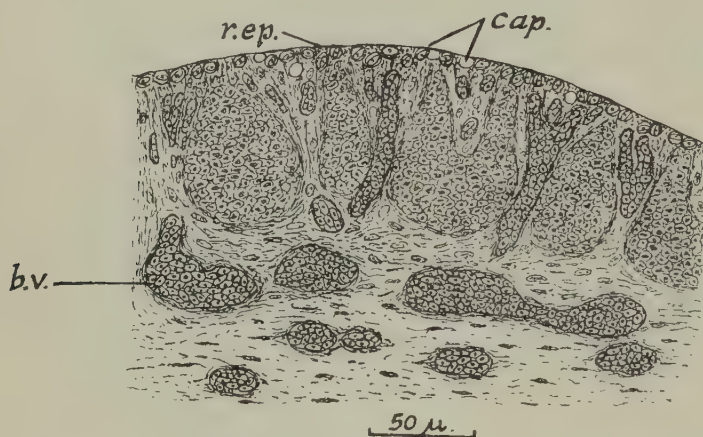


FIG. 5.—Transverse section of the respiratory epithelium of the accessory respiratory organ of *Electrophorus electricus*.

b.v., blood vessels; *c.*, supporting tissues; *cap.*, capillaries;
r.ep., respiratory epithelium.

vascular epithelia. However, I have been unable to find this tissue in the material which I have examined. I have found no tissue of any kind outside the very typical vascular epithelium which covers the prominences.

BLOOD SUPPLY OF THE ACCESSORY RESPIRATORY ORGANS.

Several fishes were dissected and the blood supply of the accessory respiratory organs was made out so far as it was possible to do so. In figs. 1 & 2 the arterial and venous supplies are shown diagrammatically in lateral view. Fig. 3 is a diagram of a transverse section of the head at the level of the first gill bar. In this figure the arterial supply is shown on the right and the venous supply on the left.

ARTERIAL SUPPLY. (Figs. 1, 3.)

The ventral aorta (*v.a.*) gives off three afferent branchial arteries, of which the last divides to supply the two posterior gill bars. The branchial arches

(*br.a.*) pass through the gill bars without breaking up into capillaries and unite dorsally to form the roots of the dorsal aorta (*d.a.*), the third arch joining the fourth before it reaches the aorta.

The branchial arches are of very unequal size. The largest is the fourth and, after this, the first, second and third follow in this order. The third arch is very narrow.

The branchial arches give off vessels to the filaments in groups of four at each level, two each to the filaments on the two sides of the gill bar. Thus, both the afferent and efferent vessels of the filaments of the normal fish gill here enter the one branchial arch, which is clearly the fused afferent and efferent branchial arteries. In *Electrophorus* the blood leaves the gill filaments by veins which will be described below: all the vessels which pass from the branchial arch to the filaments must be afferent in function in this fish.

The accessory respiratory organs in the floor of the mouth are supplied by arteries (*v.r.a.*) which leave the branchial arches at the level of the most ventral gill filament and pass backwards to the ventral side of the gill bar. Thence they go to the floor of the mouth, where they branch among the prominences. Of these vessels, that on the first branchial arch is the largest, extending far forwards. In the first gill bar, and probably also in the others, these vessels give off branches which pass dorsally along the inner side of the gill bar and supply the prominences on the inner face of the bar.

On the dorsal side of the mouth, the prominences are supplied by arteries (*d.r.a.*, *a.g.c.*) which arise from the first two branchial arches at the points where they turn backwards to join the dorsal aorta. I have been able to find these vessels on the hinder arches. A vessel on the first arch is much the largest of these and supplies almost the whole of the prominences in the roof of the mouth. The first arch also gives off a branch (*a.g.c.*) to the prominences on the wall of the gill chamber. The vessel on the second arch goes mainly to the wall of the gill chamber.

VENOUS SUPPLY. (Figs. 2, 3.)

The sinus venosus receives two large ductus Cuvieri (*d.C.*), large hepatic veins (*h.v.*) and, at its anterior side, a large and more or less median jugular vein (*j.v.*). The latter passes backwards from the floor of the mouth to the heart, lying for the greater part of its course ventral to the aorta, but passing to the dorsal side of the aorta close to the pericardium. On each side, two large veins enter the jugular vein as it passes along the aorta, one at the front end of the aorta and one midway along its length. Both of these are formed by branches from the gill bars (*br.v.*, *v.g.b.*) and others from the accessory respiratory organs of the floor of the mouth (*v.r.v.*). The anterior vein is formed by two branches, one from the first gill bar and one, which is very large, from the prominences on the anterior part of the floor of the mouth: the hinder vein is formed by branches from the three posterior gill bars and by a branch from the more posterior accessory respiratory organs of the mouth. In the first

gill bar there is a vein from the prominences on its inner face (*g.b.v.*). This vein enters the anterior of the two veins from the accessory respiratory organs. I have not been able to find corresponding veins on the posterior gill bars, but they probably exist.

On the dorsal side of the gill chamber, two veins enter the anterior cardinal vein, one at the level of the first gill bar and the other at the level of the fourth, just anterior to the point at which the anterior cardinal vein joins the ductus Cuvieri. The anterior of these is a large vein (*d.r.v.*) arising as many branches among the accessory respiratory organs on the roof of the mouth. It also receives a vein from the more dorsal of the prominences on the first gill bar. The posterior of these veins is formed by three veins (*v.g.c.*) which come from the prominences on the wall of the gill chamber at the levels of the three posterior gill bars, and by three smaller veins which drain the dorsal prominences of the inner faces of these gill bars. All these veins unite to form a longitudinal vein in the dorsal wall of the gill chamber.

It will be clear from this account of the veins which drain the accessory respiratory organs that the blood must be mixed by the time that it reaches the sinus venosus. Both the jugular vein and the anterior cardinal vein receive blood from other organs besides the accessory respiratory organs, and the blood in the posterior cardinal vein and the hepatic veins is purely venous. We should, therefore, not expect to find any tendency towards division of the heart in *Electrophorus*, for there is no possibility of arterial and venous blood being kept separate as it passes through the heart. Valentin (1842), however, stated that the heart is divided, and, in order to determine whether this is so, I dissected the heart in several fishes. I was able to find no evidence of any functional division of the heart. The sinus venosus, auricle and ventricle are completely undivided. In the bulbus there are two wide, dorsal and ventral, ridges (*b.r.*) which almost completely divide its cavity into right and left halves. But the blood is mixed when it reaches the bulbus, and these ridges can have no significance in separating arterial and venous blood. It is very hard to see what function, if any, they serve. I have been unable to find any ridges or other structures dividing the ventral aorta.

It has been noted that the branchial arches do not break up into capillaries in the gill bars. This must result in much of the blood passing directly through these vessels into the dorsal aorta. The very wide fourth arch provides an especially easy passage for the blood in this direction. The organs are supplied by the blood in the ventral and dorsal aortas, all of which is mixed, since the blood is already mixed in the heart. We, therefore, have in *Electrophorus* another example, to add to the many among air-breathing teleosts, of a fish in which the body is supplied by mixed blood, the aëration of the blood being kept up by the passage of only a proportion of the circulation through the respiratory organ at each circuit. Such a circulatory system is clearly imperfect: it is sufficient for the needs of these fishes, but it is clearly inefficient as compared with the double circulation which we find in the Dipnoi

and the terrestrial vertebrates. A double circulation is made possible when the blood from the respiratory organ is brought back to the heart by a vein distinct from that which carries the venous blood from the rest of the body, and when the heart is divided. Among the air-breathing teleosts, *Gymnarchus* alone possesses such a vein, and, in association with the development of this vein, its heart is incompletely divided. In *Gymnarchus* the respiratory organ is the air-bladder, as it is in the Dipnoi: none of the accessory respiratory organs in other parts of the body in the teleosts have a separate vein carrying their blood to the heart, although there seems no reason why such a vein should not have been evolved.

There can be no doubt that in *Gymnarchus*, and perhaps also in the Dipnoi and the ancestors of the terrestrial vertebrates, the development of a double circulation must have succeeded a stage in the evolution of air-breathing in which the circulation was mixed.

Family LORICARIIDAE.

PLECOSTOMUS PLECOSTOMUS (Linn.).

Jobert (1877-8) mentions aërial respiration in a species of *Plecostomus*, using the synonym *Hypostomus*. He describes a part of the alimentary canal,

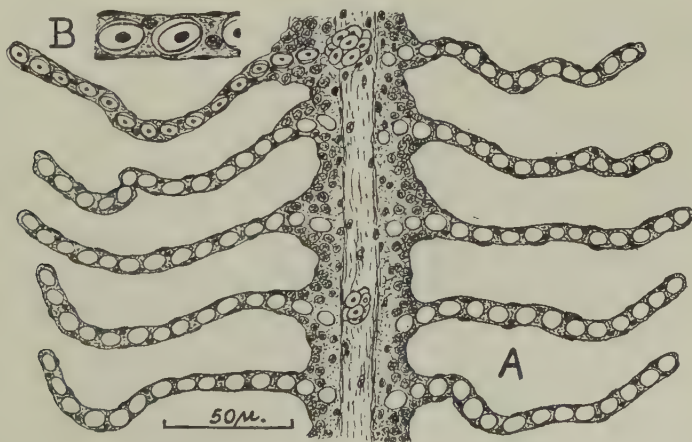


FIG. 6 — A. A longitudinal section of a gill filament of *Plecostomus plecostomus*.
B. Enlargement of part of a secondary fold.

which he considered to be the front part of the intestine, as full of air during the life of the fish and as carrying a rich plexus of blood vessels which drain into the hepatic portal vein. Except that I believe this organ to be the stomach and not the front part of the intestine—I can find no sphincter between it and the alimentary canal in front of it—I can confirm his observations so far

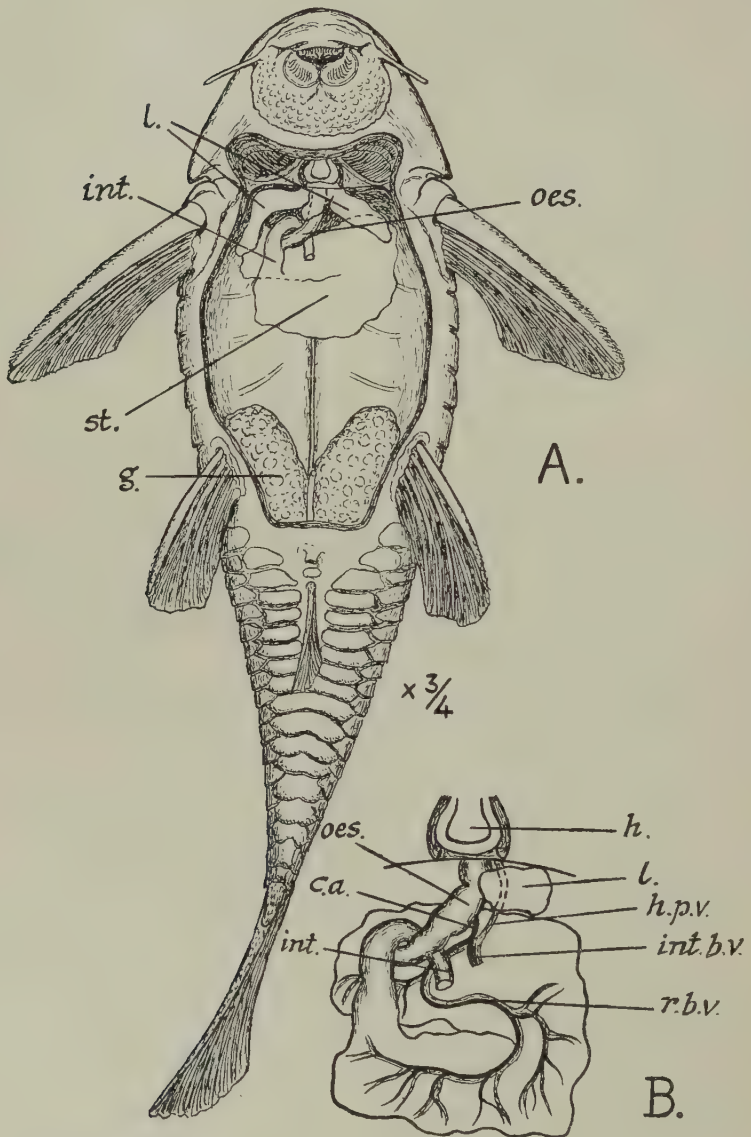


FIG. 7.—*Plecostomus plecostomus*. A. A view of the body cavity after removal of the greater part of the intestine. B. An enlarged view of the respiratory stomach.
c.a., coeliac artery; *g.*, gonad; *h.*, heart; *h.p.v.*, hepatic portal vein; *int.*, intestine; *int.b.v.*, blood vessels supplying the intestine; *l.*, liver; *oes.*, oesophagus; *r.b.v.*, respiratory blood vessels; *st.*, stomach,

as they go. He gives no figure and no details of the histology and the arterial supply.

Since Jobert's time, the accessory respiratory organ of this fish seems never to have been investigated.

A respiratory stomach in another member of the Loricariidae, *Ancistrus anisitsi* Eigenmann & Kennedy, was described in the earlier paper which dealt with the fishes of the swamps of the Paraguayan Chaco (Carter & Beadle, 1931). The accessory respiratory organs of *Plecostomus* and *Ancistrus* resemble each other in the main outlines of their structure, but there are some considerable differences between them and these will be mentioned in the following account.

Plecostomus lived for many days in small vessels of water in our laboratory. It was found to come to the surface of the water frequently and to take in air, which was allowed to escape at the gill opening.

In this fish the mouth, oesophagus and gill chamber are normal and show no organ which it is possible to regard as an accessory organ of respiration. The gill filaments (fig. 6) are well developed and of a form typical of these organs in the fishes of tropical stagnant waters. The secondary folds are broad and thin, and the epithelium over them is very low. The structure of the folds suggests that the fish could probably live by aquatic respiration in well aerated water, but I have no observations on this point.

When the body cavity is opened, the stomach is found to lie dorsal to the intestine, which has very numerous coils and forms a thick pad of tissue in the ventral part of the body cavity. The stomach lies free in the body cavity and is not enclosed in a separated part of the cavity, as the respiratory stomach of *Ancistrus* is (Carter & Beadle, 1931). Its appearance after the intestine has been removed is shown in fig. 7, A. The oesophagus bends to the right after it enters the body cavity and expands to form the stomach, turning upon itself. The stomach occupies three sides of a square, the fourth side, that on the fish's right, being formed by the first part of the intestine.

The blood supply of the stomach (fig. 7, B) consists of branches of the coeliac artery (*c.a.*) and the hepatic portal vein (*h.p.v.*). The artery passes ventrally from the aorta up the anterior wall of the stomach and thence on to its ventral face. Near the front edge of the stomach it gives off a large respiratory artery, which ramifies over the stomach wall, the main branch of the artery passing onwards to the intestine. The hepatic portal vein lies close to the coeliac artery between the intestine and the stomach, and receives a large respiratory vein close to the point where the coeliac artery gives off its respiratory branch. From this point the portal vein passes forwards into the liver, which it traverses without breaking up into capillaries. The respiratory vein arises on the stomach wall as many branches (*r.b.v.*) which, in general, lie parallel to the branches of the respiratory artery.

The wall of the stomach is very thin and papery and, in life, transparent. The blood plexus in the wall is much denser over the more posterior parts of

the stomach. Indeed, the anterior parts of the stomach wall are not noticeably vascular.

A section through a part of the vascular wall of the hinder part of the stomach is shown in fig. 8. Within the coelomic epithelium (*c.ep.*) are thin layers of transverse and longitudinal muscle (*mu.*), and a much thicker layer of connective

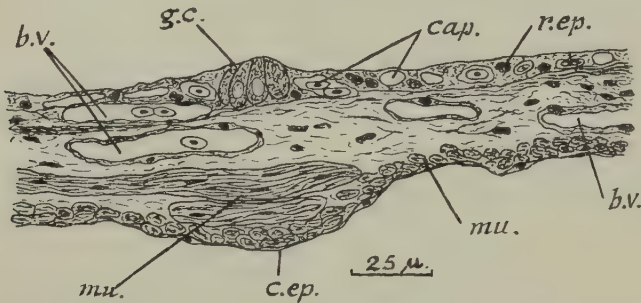


FIG. 8.—Transverse section of the respiratory wall of the stomach of *Plecostomus plecostomus*. Lettering as in fig. 5 and :—
c.ep., coelomic epithelium; *g.c.*, gland cells; *mu.*, muscle.

tissue which contains many blood vessels (*b.v.*). The epithelium on the inner face of the wall (*r.ep.*) is only moderately high : it is clearly not digestive. It contains a rich supply of capillaries (*cap.*). Groups of gland cells (*g.c.*) occur scattered through the epithelium. Near the place where the intestine opens

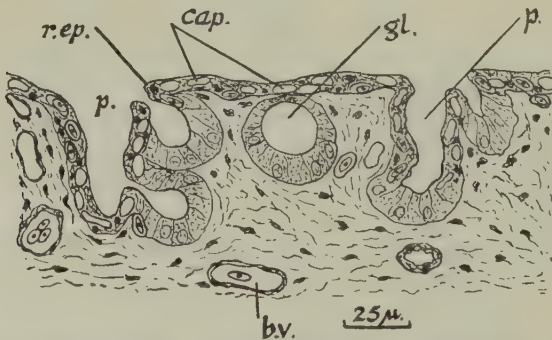


FIG. 9.—Transverse section of the more glandular part of the stomach wall of *Plecostomus plecostomus* near the point of origin of the intestine. Lettering as in fig. 5 and :—

gl., gland; *p.*, pits into which the glands open.

out of the stomach, the glandular elements of the stomach wall are better developed and the wall itself is much thicker, although it is still vascular. Here, the gland cells are arranged in spherical glands (*gl.*), sometimes sunk in pits (*p.*), the walls of which are vascular.

From this account it will be seen that the structure of the stomach wall of *Plecostomus* resembles that of the wall of the respiratory stomach of *Ancistrus* in many ways. The chief differences between these organs are that the stomach of *Plecostomus* is not enclosed in a separated part of the body cavity, that more gland cells are present in its wall and that the respiratory vein of *Plecostomus* is a branch of the hepatic portal vein and not, as it is in *Ancistrus*, of the interrenal vein. None of these differences seem to be of any great functional importance.

The vascularity of the stomach wall in *Plecostomus*, its non-digestive character, and the facts (1) that the fish habitually takes in air, (2) that the stomach is full of air during the life of the fish, and (3) that no other organs which can be regarded as organs of aërial respiration are to be found, together leave no doubt that the stomach of this fish is an accessory respiratory organ.

SUMMARY.

1. Some observations on the oecology of various fishes which live in forest waters of several types in British Guiana are given. These observations are mainly concerned with the respiratory adaptations of the fishes.

2. An account is given of the structure and blood supply of the accessory respiratory organs of the electric eel, *Electrophorus electricus* (Linn.), and *Plecostomus plecostomus* (Linn.).

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Coleoptera associated with the giant *Lobelias* and arborescent *Senecios* of eastern Africa. By HUGH SCOTT, Sc.D., F.L.S. (Department of Entomology, British Museum (Natural History)); with a Supplement by Dr. MAX BERNHAUER (Horn, N.-Oe., Austria).

(With 14 Text-figures)

[Read 21 February 1935]

PART I: INTRODUCTION.

The giant *Lobelias* and arborescent *Senecios* constitute one of the most arresting features of the isolated alpine floras of eastern Africa. Attaining gigantic size, even in high alpine regions where the vegetation is otherwise almost entirely dwarf, and assuming extraordinary forms, they are also remarkable in their distribution and affinities. The arborescent *Senecios*, as a whole, are more localized, being confined to the east African mountains. The giant *Lobelias* have close relatives in several parts of the Tropics outside Africa, and a wider range than the *Senecios* within that continent. They extend over more than 20° of latitude, from northern Abyssinia to southern Tanganyika Territory, and over about 10° of longitude, from Ruwenzori and the Birunga Mountains eastwards to Kilimanjaro and Usambara. Their distribution presents a high degree of discontinuity; while some species occur on several isolated mountain-massifs separated by great distances, others are restricted to few massifs, or even to a single one*. Their altitudinal range on the various mountains is also clearly delimited. The discovery of an assemblage of insect-species intimately associated with these plants is, therefore, of great interest.

My interest in this subject was aroused through discovering, in Abyssinia, in October and November 1926, some species associated with two species of giant *Lobelias*, and already, in 1931, certain Staphylinidae had been described and some remarks of mine on the beetles attached to *Lobelia Rhyncho-petalum* had been published†. I suspected that an assemblage of species

* These general statements about *Lobelias* and *Senecios* are gathered from Miss E. A. Bruce, 'The giant *Lobelias* of East Africa', Kew Bulletin of Miscellaneous Information, no. 2, pp. 61-88, 1934, and from Prof. L. Hauman, 'Les *Lobelias* géants', Mémoire publié par l'Institut Royal Colonial Belge, Tome ii (8vo), 1933. Several maps and tables, as well as reproductions of photographs, are included in these works.

† In Bernhauer and Scott, Ent. Exp. to Abyssinia, Staphylinidae (Journ. Linn. Soc. xxxvii, p. 564, Nov. 1931). Hancock collected some beetles from *Lobelias* on Mt. Elgon in August 1929, and certain species were mentioned in his article, cited below, which appeared in January 1931. The description of one of them, by Dr. Bernhauer, appears for the first time in the Supplement to the present paper.

associated with these plants could be brought to light, comparable in extent with that attached to the arborescent Euphorbias in the Canaries and other Atlantic archipelagoes, and in Southern Morocco. I proceeded, therefore, early in 1934, to study the Abyssinian species of families other than Staphylinidae which had been collected from these plants, and, at the same time, those obtained by Mr. G. L. R. Hancock from giant Lobelias and Senecios during his expedition to Ruwenzori, with Mr. C. W. L. Fishlock in 1931. Further small lots of material came to hand, collected by Mr. E. G. Gibbins in the Birunga Mountains, December 1932; by Mr. W. J. Eggeling in Ruwenzori, August 1933; and by Mr. H. B. Johnston on Mt. Elgon in March 1934. Moreover, Dr. Jeannel has kindly submitted to me, from the Paris Museum, the Cryptophagidae obtained by himself and his colleagues on various east African mountains during the recent Mission de l'Omo, and has allowed me to select for immediate study the specimens taken from Lobelias and Senecios, and the same applies to the older material collected by Monsieur C. Alluaud and Dr. Jeannel during their 'Voyage en Afrique Orientale' in 1911 and 1912. Lastly, I have had before me, from the Congo Museum at Tervueren, numerous specimens of Clavicorns of several species, collected by Monsieur L. Burgeon in West Ruwenzori in July 1932; in this material, unfortunately, the specimens from Lobelias, Senecios, and Helichrysums were not kept apart, but the species of Coleoptera are identical with, or closely related to, those received from other parts of Ruwenzori.

A study of all this material has resulted in the description, in the present paper, of seventeen new species: Corylophidae (two), Cryptophagidae (fourteen), Scolytidae (one). I have, further, searched the published results of other expeditions and certain scattered papers for records*.

The total, including fourteen of the species described below (but excluding the other three, because, though congeneric with certain of the Lobelia-haunting species, they were not themselves taken from Lobelias or Senecios), is a list

* The principal works consulted are: Y. Sjöstedt, 'Zoologische Kilimandjaro-Meru Expedition', 1905-6, vol. i, 1910 (section 1, 'Die Tierwelt der Steppen und Berge', and section 7, Coleoptera); all published parts (1913-29) on Coleoptera of the 'Voyage de Ch. Alluaud et R. Jeannel en Afrique Orientale, 1911-12'; all the reports on Coleoptera which have so far appeared in the 'Sammlungen der schwedischen Elgon-Expedition im Jahre 1920' (Arkiv för Zoologi, vol. xiv, 1921-2 and onwards); papers on the Coleoptera collected in West Ruwenzori by L. Burgeon, published in the 'Revue de Zoologie et de Botanique Africaines' (vol. xxiv, 1933, and onwards); G. L. R. Hancock and W. W. Soundy, 'Notes on the fauna and flora of Northern Bugishu and Masaba (Elgon)', Journal of the East Africa and Uganda Natural History Society, no. 36, pp. 165-83, 1929 (publ. Jan. 1931); and C. W. L. Fishlock and G. L. R. Hancock, 'Notes on the flora and fauna of Ruwenzori, with special reference to the Bujuku Valley', in the same Journal, no. 44, pp. 205-29, 1932 (publ. Jan. 1933). No reference to Coleoptera associated with these plants has been found in the 'Zoological results of the Ruwenzori Expedition, 1905-6' (Trans. Zool. Soc. xix, 1909-10).

of forty-nine species, representing thirteen families. Nor can it be claimed that the list is complete, since additional species will surely come to light, especially when the collections of the recent Mission de l'Omo and of the present British Museum Expedition to East Africa, under the leadership of Dr. F. W. Edwards, are fully studied. Further, though Coleoptera possibly predominate in this association, insects of other orders will be found to have a place in it too. Sjöstedt (op. cit.) has already recorded a Dermapteron as numerous in dry inflorescences of *Lobelia Deckenii* in Kilimanjaro.

The Table (pp. 238–41) includes a list of the forty-nine species, and indicates the condition of the wings, the plants on which each species has been found, and the part of the plant affected, the locality and altitude, and (lastly) whether the beetles have been obtained exclusively in this peculiar habitat or not. The following facts can be summarized :—

Restriction to *Lobelias* and *Senecios* ; Biology.

As shown in the last column, only four species (a Staphylinid, a Coccinellid, an Anthicid, and a Hispine Chrysomelid) are widely distributed, and, therefore, merely casual visitors to the plants ; moreover, even among these, the Anthicid is represented by a peculiar variety, not hitherto found elsewhere. The remaining species are mostly based on material taken, usually in numbers from moderately to very large, only from these plants. Even those species (ten in number) in which some of the specimens were found apart from the plants are known only from small areas at high altitudes, in close proximity to the plants. Considering how many of them are flightless, their range is unlikely to be very wide. Even if some of the species do occur on other plants and in other habitats within the restricted zones of altitude of their respective *Lobelias* and *Senecios*, these plants still appear to have a special attraction for them : for instance, careful search on the surrounding moorland of the summit of Mt. Chillálo, Abyssinia, failed to reveal any specimens of *Atheta lobeliae* or *Mnionomus rhynchopetali*, though both these were found in numbers in the decaying *Lobelia*-stems ; and specimens of *Thamnurgus zukwala* were obtained only from a dying *Lobelia*-inflorescence, although the surrounding small patch of forest on Mt. Zukwala was full of flowers of many other kinds. Probably the flower-haunting species are in a high degree restricted to their particular plants—e.g. most of the species of *Mnionomus* have been found in the inflorescences of *Lobelias*, but on Mt. Chillálo, where the *Lobelias* were not in flower, *M. rhynchopetali* occurred in large numbers under the bark ; and those species of this genus discovered in flowers of Everlastings (*Helichrysum*) on Mt. Elgon may well have resorted to those flowers owing to the lack of others, for Mr. Johnston tells me that, the dry season being at its height and the time of his visit extra dry, other flowers were almost entirely wanting.

The question of restriction to the plants is closely bound up with the biology

TABLE OF COLEOPTERA ASSOCIATED WITH GIANT LOBELIAS AND SENECIOS.

In the Table the following symbols are used :—

- (i) in the second column, W = fully winged, V = wings vestigial, A = apterous, F = flightless (this last symbol is used in the case of the Curculionidae, in which the wings are not functional, but their exact condition, whether reduced or absent, is not stated in the descriptions).
- (ii) in the fifth column, X = species hitherto found only in association with *Lobelia* or *Senecio*,
 Y = species also found in other habitats, but only in restricted areas at high altitudes.
 Z = widely distributed species, casual visitors to these plants.

It has been necessary to write 'X' or 'Y' in a few cases, when it is not clear from the data whether all, or only part, of the material was obtained from *Lobelia* or *Senecio*.

Altitudes are given as precisely as possible, from the data with the insects; but when the range of altitude covers several thousand feet, it does not follow that the species has been found to occur throughout the whole range.

STAPHYLINIDAE.		W	<i>Lobelia Rhynchopetalum</i> (under bark of decaying stem).	Mt. Chilláló, Abyssinia, over 12,000 ft.	Z
<i>Megarhtrus abessinus</i> Bernh., 1931					
<i>Onalium algidum</i> Fauv., 1907	W	<i>Lobelia Rhynchopetalum</i> (under bark of decaying stem).	Mt. Chilláló, Abyssinia, over 12,000 ft.	Y	
— <i>algidum</i> subsp. <i>burgeoni</i> Bernh., 1934.	W	<i>Lobelia Bequaertii</i> (seeding inflorescences); <i>Lobelia Wollastonii</i> (inflorescences).	Ruwenzori (Bujuku, 10,800–12,000 ft., and West Ruwenzori, 13,800 ft.).	X	
<i>Atheta lobeliae</i> Bernh., 1931	W	<i>Lobelia Rhynchopetalum</i> (under bark of decaying stem).	Mt. Chilláló, Abyssinia, over 12,000 ft.	X	
— <i>paludosa</i> Bernh., 1931	W	<i>Lobelia Rhynchopetalum</i> (under bark of decaying stem).	Mt. Chilláló, Abyssinia, over 12,000 ft.	Y	
— <i>suprema</i> Bernh.*	W	<i>Senecio adnivalis</i> and/or <i>S. erioneuron</i> (flowers).	Ruwenzori (Bujuku, 12,500 ft.).	X	
<i>Troposipalia hancocki</i> Bernh.*	A	<i>Lobelia elgonensis</i> (under decaying leaves).	Mt. Elgon, above 12,000 ft.	X	
SILPHIDAE.					
<i>Oritocatops lobeliae</i> Jeannel, sp. n.†	A	<i>Lobelia</i> sp. (larvae and adults inside dry stems of inflorescences).	Mt. Elgon, 13,000 ft.	X	

CORYLOPHIDAE.

Corylophus lobelicola, sp. n.
Orthoperus ruwenzoriensis, sp. n.

NITIDULIDAE.

Meligethes gloriosus Grouvelle, 1909 ..
 — *subcaeruleus* Grouvelle, 1909
 — *sjöstedti* Grouvelle, 1909
 And possibly other species †

CRYPTOPHAGIDAE.

Mnionomus § *alluaui*, sp. n.
 — *burgeoni*, sp. n.
 — *rhynchopetali*, sp. n.
 — *jeanneli*, sp. n.
 — *hancocki*, sp. n.
 — *gibbinsi*, sp. n.
Micrambe senecionis, sp. n.
 — *kigoensis*, sp. n.
 — *eggelingi*, sp. n.
 — *varicolor* Grouv., 1909

Lobelia Bequaertii (inflorescences).
 { *Lobelia Bequaertii* (inflorescences).
Lobelia bambuseti.
 }
Lobelia Deckenii (dry inflorescences).
Senecio keniodendron.
Lobelia Bequaertii (seeding inflorescence)
 and probably other species.
Lobelia Rhynchopetalum (under bark of
 dead stem).
Senecio keniodendron.
Lobelia Wollastonii and *L. Bequaertii*
 (seeding inflorescences in both cases).
Lobelia sp. (probably *L. Wollastonii* or
L. karisimbensis).
Senecio sp. (*S. adnivalis* or *S. erioneuron*;
 on the flower-heads).
Lobelia Bequaertii (inflorescences) and
 possibly other species.
Lobelia Bequaertii (seeding inflores-
 cence).
Lobelia Deckenii (old inflorescences).

Ruwenzori, 11,000 ft.
 Ruwenzori, 11,000 ft.
 Mt. Kenya, c. 10,000 ft.
 Mt. Kilimanjaro, 11,000 ft.
 Mt. Kenya, 10,800–14,400 ft.
 Ruwenzori, 10,800–13,800 ft.
 Mt. Chillálo, Abyssinia, over 12,000 ft.
 Mt. Kenya, 11,500–14,400 ft.
 Ruwenzori, 10,800–12,000 ft.
 Muhavura, Birunga Mts., 12,000 ft.
 Ruwenzori, 12,000 ft.
 Ruwenzori, 11,000–13,800 ft.
 Ruwenzori, 10,800 ft.
 Mt. Kilimanjaro, between 9,800 and
 13,000 ft.

X
 X
 }
 ? Y
 Y
 ? Y
 X
 X
 X
 X
 X
 ? Y
 X
 X

* See the Supplement, p. 283, for these two species of Staphylinidae.

† The description of this species, discovered during the recent Mission de l'Omo, will appear shortly in a work by Dr. Jeannel.

‡ See Sjöstedt, Kilimandjaro-Meru Exp. i, 1 ('Die Tierwelt der Steppen und Berge'), p. 33, 1909.

§ Three other species of *Mnionomus* are described in this paper, but are excluded from the Table, as they were not found definitely associated with *Lobelias* or *Senecios*.

TABLE (continued).

CRYPTOPHAGIDAE (cont.).	V	<i>Lobelia Deckenii</i> (old inflorescences).	Mt. Kilimanjaro, between 9,800 and 13,000 ft.	? X
<i>Micrambe subinfuscata</i> Grouv., 1909 ..				
— <i>bujukuensis</i> , sp. n.	W	<i>Lobelia Bequaertii</i> (seeding inflorescences).	Ruwenzori, 10,800 ft.	X
<i>Atomaria chilaloensis</i> , sp. n.	W	<i>Lobelia Rhynchopetalum</i> (under bark of dead stem).	Mt. Chillalo, Abyssinia, over 12,000 ft.	? Y
BIPHYLLOIDAE.				
<i>Biphylus</i> , 2 spp.*	W	<i>Lobelia bambuseti</i> (mostly) and <i>L. giberroa</i> var. <i>utugurensis</i> (a few; in both cases in the inflorescences, in numbers).	Mt. Kenya, mostly about 9,100 ft., a few specimens also at about 6,500 ft.	? Y
COCCINELLIDAE.				
<i>Adalia sexareata</i> Weise, 1897	W	<i>Lobelia Deckenii</i> (flowers).	Mt. Kilimanjaro, between 9,800 and 11,500 ft.	Z
CYPHONIDAE.				
<i>Cyphon atrovittatus</i> Pic, 1914	?	<i>Lobelia</i> sp. (siftings of debris).	Mt. Kenya, about 9,100 ft.	Y
CLERIDAE.				
<i>Apteroclerus brevis</i> Schenkling, 1909	A	<i>Lobelia Deckenii</i> (dry inflorescences).	Mt. Kilimanjaro, between 10,000 and 11,500 ft.	X
ANTHICIDAE.				
<i>Formicomus gestroi</i> Pic var. <i>semiobscurus</i> Pic, 1914.	W	<i>Senecio adnivalis</i> .	Ruwenzori, 11,500 ft.	Z †
CHRYSOMELIDAE.				
<i>Sjoestedinia montivaga</i> Weise, 1909	A	<i>Lobelia Deckenii</i> (over 80 specimens from dry inflorescences).	Mt. Kilimanjaro, 9,800–11,500 ft.	X
<i>Trichispa sericea</i> Guér., 1844	W	<i>Senecio adnivalis</i> .	Ruwenzori, 11,500 ft.	Z

CURCULIONIDAE.

Otiorrhynchinae.

<i>Parasystates minor</i> Auriv., 1909	F	<i>Lobelia Dechenii</i> (old dry inflorescences).	Mt. Kilimanjaro, 9,800-13,000 ft.	X
— <i>burgoni</i> Marshall, 1933	F	<i>Senecio</i> sp.	Ruwenzori, 13,700 ft.	X
— <i>nodipennis</i> Marshall (MS.)	F	<i>Senecio Erici-Rosenii</i> (and possibly <i>S. alticola</i>).	Muhavura, Birunga Mts., 11,000-13,400 ft.	X
<i>Subleptospyris turbida</i> Marshall, 1932 ..	F	<i>Senecio</i> sp.	Ruwenzori, 12,000 ft.	X
<i>Xestorrhynchus lobeliae</i> Auriv., 1926 ..	F	<i>Lobelia</i> spp. (the beetles in great numbers).	Mt. Elgon, between 8,000 and 13,000 ft.	X
<i>Neoteripclus granulipennis</i> Hust., 1923 (<i>Seneciobius lovénii</i> Auriv., 1926).	F	<i>Senecio</i> spp. (adults eat the leaves).	Mt. Elgon, between 10,800-13,000 ft.	X
— <i>nitidipennis</i> (Auriv., 1926)	F	{ <i>Senecio</i> spp.	{ Mt. Elgon, various altitudes between 7,500 and 13,000 ft.	X
— <i>pustulosus</i> (Auriv., 1926)				
— <i>laevis</i> (Auriv., 1926)				
— <i>granulifer</i> (Auriv., 1926)				
<i>Hyposomius lobeliae</i> Auriv., 1909	F	<i>Lobelia Dechenii</i> (about 50 examples from old dry inflorescences).	Mt. Kilimanjaro, 9,800-13,100 ft.	X
Cossoninae.				
<i>Cossonus lobeliae</i> Auriv., 1909	?	<i>Lobelia Dechenii</i> (old dry inflorescences).	Mt. Kilimanjaro, 9,800-14,400 ft.	X
<i>Pseudomesites ruwenzoriensis</i> Hust., 1929 (<i>lobeliae</i> Marshall, 1932).	F	<i>Lobelia</i> sp. (? <i>L. Wollastonii</i>) (breeds in seed-capsules).	Ruwenzori, 12,000 ft.	X
<i>Pseudomesites senecionis</i> Marshall, 1933.	F	<i>Senecio</i> sp. (under bark).	Ruwenzori, 13,700 ft.	X
SCOLYTIDAE.				
<i>Thamnurqus lobeliae</i> Eggers, 1933	W	<i>Lobelia Bequaertii</i> and <i>L. Wollastonii</i> (flowers and seed-capsules).	Ruwenzori, 11,000-12,000 ft.	X
— <i>zukunftae</i> , sp. n.	W	<i>Lobelia gibberoa</i> (on feid dying inflorescence).	Mt. Zukwala, Abyssinia, 9,600 ft.	X

* These two species of *Biphylus*, almost certainly undescribed, are represented by long series of specimens in the material of the 'Voyage Allaud et Jeannel en Afrique Orientale' (1911-12). The description of them must be deferred until a number of African species, awaiting study, can be investigated.

+ The typical form of *Formicomus gestroi* is widely distributed in eastern Africa; the variety has apparently only been found on *Senecio*.

of the insects. About this there is, as yet, little information, and we are compelled to judge largely from the biology of related forms. The species most likely to be entirely restricted to the plants are: (a) the remarkable Silphid discovered by Dr. Jeannel, which appears to pass its entire life-cycle inside the stems of the inflorescences of a *Lobelia*, and (b) the Curculionidae and, possibly, the Scolytidae and a species of Chrysomelidae. Of the Curculionidae, one of the two species of *Pseudomesites* is recorded to breed in the seed-capsules of a *Lobelia*, an unusual situation for members of the subfamily Cossoninae, while the other species was found under the bark of a *Senecio*, a normal situation for weevils of that subfamily. The Otiorrhynchines are, judging from the known biology of other members of the group, probably root-feeders in the larval stage, and the adults of at least one species are recorded to eat the leaves of the *Senecios* on which they occur*. As to the Scolytidae, the Palaearctic species of *Thamnurgus* mine, in the larval stage, in the stalks of herbaceous plants; the two species associated with *Lobelias*, found only in the inflorescences, may breed in the seed-capsules. The wingless Chrysomelid which frequents *Lobelia*-flowers in Mt. Kilimanjaro may feed, in its larval stage, on the leaves.

Regarding the small Clavicorns, which account for nearly all the new species described here, the Corylophidae usually live in decaying vegetable matter, and the occurrence of two species in large numbers in *Lobelia*-inflorescences is remarkable. The occurrence of the various species of Cryptophagidae in the flowers, or (in one case) under the bark, is normal for the genera concerned, certain members of which are known to feed on excrement of other insects in the larval stage, while the adults are found in decaying vegetable matter and in flowers.

Though several species of Coleoptera affect more than one species of either *Lobelia* or *Senecio*, none has yet been found on plants of both genera.

Endemism ; Flightlessness ; Affinities ; Exceptional size.

Disregarding the few widespread species, many of those peculiar to *Lobelias* or *Senecios* belong to widely distributed genera. Most of the Curculionidae, however, belong to genera of restricted range, some of which, such as *Neoteripelus* (*Seneciobius*) and *Pseudomesites*, contain no known species other than those associated with these plants. The same applies to the monotypic genus of apterous Chrysomelidae, *Sjoestedtinia*.

But if many of the genera are wide-ranging, the species display a very high degree of endemism. With one exception (again disregarding the few casual visitors), none has yet been found in more than one mountain-massif of eastern Africa. The single exception is *Orthoperus ruwenzoriensis*, recorded from Ruwenzori and Mt. Kenya; owing to its minute size and fully-

* See Aurivillius, in Lovén, 'Kring Mount Elgon', ed. 1, p. 93, fig. 1 and legend, 1921.

developed wings, the aerial transport of specimens over long distances is conceivable. Several genera (*Mnionomus*, *Micrambe*, *Parasystates*) are represented by one or more distinct species in the several mountain-massifs.

In connexion with the restricted distribution of the beetles, their powers of flight must be considered. Out of the forty-five species peculiarly associated with *Lobelia* or *Senecio*, twenty-two have the wings either reduced to vestiges or entirely atrophied. In a few cases, such as *Corylophus lobelicola*, reduction of the wings is a specific feature, not characteristic of the genus as a whole. But most of the flightless species are members of groups in which reduction or atrophy of the wings is widespread or general. This condition is one of the generic characters of *Mnionomus*, and in the Otiorrhynchine Curculionidae it characterises entire groups of genera. A consideration of the theoretical bearings of the high percentage of flightless forms among the *Lobelia*- and *Senecio*-beetles must be deferred for the present. But it may be remarked that flightless Otiorrhynchinae abound in plains as well as in mountains. *Mnionomus*, on the other hand, appears to be a characteristically mountain genus, both in the Ethiopian and Palaearctic Regions.

As to geographical affinities, the peculiar genera are probably specialized components of the fauna of the Ethiopian Region, and many of the species belonging to widespread genera may also be of African origin. The genus *Thamnurgus* was, however, previously known only from the Palaearctic. The same applies to *Mnionomus*, but reasons are given below (in remarks under the headings 'Cryptophagidae' and '*Micrambe*') for uncertainty as to whether the species have arisen independently in the Palaearctic and Ethiopian Regions, by successive stages in wing-reduction and accompanying structural changes, or whether the African species are relicts of a former southward extension of the Palaearctic fauna.

The association between the insects and the plants may be a very ancient one, and there is the possibility of species of plants and insects having evolved together. It is remarkable that, while these *Lobelias* and *Senecios* are giant members of their respective genera, some of the Coleoptera are also gigantic in comparison with other species of their own and related genera. *Mnionomus hancocki*, often attaining a length of 4 mm., and *Micrambe senecionis*, reaching 3 mm., are veritable giants among their congeners, and most of the species of these genera associated with *Lobelias* or *Senecios* are large in comparison with the species not associated with those plants. The two species of *Corylophidae* are also among the larger members of their respective genera.

The hypothesis has been put forward that the giant *Lobelias* originated from ancestral forms in the primitive forest zone, and that their most striking features are adaptations to the higher altitude and more severe climate*. This should be borne in mind when the possibility of a very ancient association between plants and insects, and of parallel evolution of species, is considered.

* See E. A. Bruce, op. cit., p. 61.

Possible agency in pollination.

Professor L. Hauman has recently expressed the view that autogamy is probably of normal occurrence in the giant *Lobelias**, since large flying insects are wanting at these high altitudes, and wind-pollination is unlikely to be more than occasional, owing to the great humidity; while the sun-birds (*Nectarinia*), which visit the flowers even at very high altitudes, are too few to play more than an accessory rôle in fertilization of the flowers. Perhaps some of the flower-haunting Coleoptera enumerated here, especially those with fully developed wings, are agents in pollination. (Incidentally, Hauman remarks that the sun-birds seek small insects in the inflorescences, as he has proved by examination of their crop-contents.)

Determination of the *Lobelias* and *Senecios* mentioned.

The determination of the *Lobelias* from which I collected insects in Abyssinia, and of the *Lobelias* and *Senecios* from which Hancock and others obtained them in Ruwenzori, is due to Kew. As regards the earlier expeditions, I have accepted the names in the literature or attached to the specimens; and checked those of the *Lobelias* with the Tables of Distribution and Altitudinal Range in Miss Bruce's article cited above.

To avoid repeating the names of the botanists who described the plants with every allusion to the latter, the following list is given of all the species mentioned in this paper :—

Lobelia bambuseti R. E. Fries & T. C. E. Fries.

— *Bequaertii* De Wildeman.

— *Deckenii* Hemsley.

— *elgonensis* R. E. Fries & T. C. E. Fries.

— *giberroa* Hemsley, and var. *ulugurensis* (Engler) Hauman.

— *karisimbensis* R. E. Fries & T. C. E. Fries.

— *Rhynchoptalum* (Hochstetter) Hemsley (synonym, *Rhynchoptalum montanum* Fresenius).

— *Telekii* Schweinfurth.

— *Wollastonii* E. G. Baker.

Senecio adnivalis Stapf.

— *alticola* T. C. E. Fries.

— *erioneuron* Cotton.

— *Erici-Rosenii* R. E. Fries & T. C. E. Fries.

— *keniodendron* R. E. Fries & T. C. E. Fries.

* Op. cit., pp. 15–17. In another work Prof. Hauman also alludes to autogamy as a possible, or even more or less regular, occurrence in the *Senecios*: ‘ Esquisse de la végétation des hautes altitudes sur le Ruwenzori ’, Bull. Acad. roy. Belgique (classe des sciences), ser. 5, tome xix, pp. 702–17, 1933,

Location of Types.

Those of all the Coleoptera described are in the British Museum, excepting *Mnionomus alluaudi*, *M. jeanneli*, and *M. crateris*, of which the types will be in the Paris Museum, but paratypes will be retained in the British Museum.

PART II : SYSTEMATIC.

Corylophidae.

These insects are the most minute Coleoptera known, excepting Trichopterygiidae (Ptiliidae). The two species described here belong to genera, *Corylophus* and *Orthoperus*, both of which are known to be represented in several of the great zoo-geographical regions, while the fact that such minute insects are easily overlooked renders it possible that representatives of these genera may subsequently be found in regions where they are at present unknown (excepting, possibly, Australia). It appears that only one species of each genus has previously been described from Tropical Africa, but there is evidently no lack of Corylophidae as a whole in the Ethiopian Region, since several genera are represented in the material, at present unworked, which I obtained in Abyssinia in 1926-7. Twelve species, representing eight genera, were discovered in the Seychelles in 1908-9; but, while these were minute even in comparison with their congeners in other lands, the two species described below are among the larger members of their respective genera.

The new species of *Corylophus* has the hind wings reduced to minute vestiges, but it is not the only flightless member of the genus on record, another, known only from Madeira, also exhibiting this condition. The new species of *Orthoperus* is fully winged, as seems normal in that genus.

Under both species I have called attention to certain secondary sexual characters of the male, one of which I had already described and figured when dealing with the Seychellean material (see references given below). This character, the incurving of the front tibiae (see figs. 3, 5), has been erroneously mentioned as a generic character, or used to separate species, without regard to sex, in certain works on the British and European faunas.

CORYLOPHUS Stephens, 1832.

The following species, though flightless in both sexes, is placed in this genus, as it is typical in its general form and in the structural details of the antennæ, mouth-parts, and underside. Moreover, though the genus was defined by Matthews (Mon. Corylophidae, p. 135, 1899) as having 'alae amplissimae', and I have seen the ample hind wings in several species, it does include at least one other flightless species, namely, *C. tectiformis* Wollaston (Madeira); Wollaston himself described (Ins. Mader. pp. 479, 480, 1854) the latter as being 'entirely apterous', a fact overlooked by Matthews in his Monograph. It is noteworthy that *C. tectiformis* resembles the new species (*C. lobelicola*) described below in some other respects besides atrophy of the hind wings.

In *C. lobelicola* the hind wings have not completely disappeared, but are reduced to minute vestiges; one of these (belonging to a female example) is shown in fig. 1, drawn from a balsam-preparation, and is a little over 0.1 mm. long, while the elytron is nearly 1.0 mm. long*. I have been unable to dissect a specimen of *C. tectiformis* Woll. under a high power, to confirm Wollaston's statement that the species is entirely apterous†.

Antennae.—In this genus the antennae are regarded as composed of nine segments. In balsam-preparations of the antennae of *C. lobelicola*, viewed under a high power, two very short, incomplete, chitinous rings are visible (fig. 1, *a, a*), one intercalated between the third and fourth, the other between the fourth and fifth, segments; when the antenna is lying in a certain position

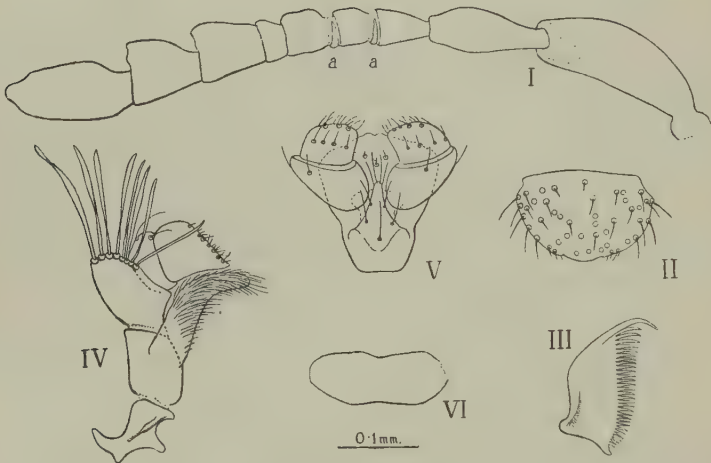


FIG. 1.—*Corylophus lobelicola*: I, antenna (*a, a*, incomplete chitinous rings intercalated between segments); II, labrum; III, mandible; IV, maxilla; V, labium; VI, vestigial wing. The 0.1 mm. line gives the scale of all the parts.

these rings appear complete, and may almost be taken for additional segments. It is impossible to say whether they are vestigial segments, indicating an intermediate stage in the process of reduction from eleven to nine segments, or whether they are due to secondary chitination of the membrane between the segments. Similar short rings are visible in the original balsam-mounts made by Matthews of the antennae of more than one species of *Corylophus*,

* The actual measurements, as nearly accurately as I can take them with a micrometer eyepiece and slide, are: elytron, c. 0.95 mm.; wing, c. 0.115 mm.

† Among the flightless Coleoptera included in the fauna of the Seychelles are several in which minute vestiges of the hind wings remain. These are enumerated in the section on reduction of wings in my 'General conclusions regarding the insect fauna of the Seychelles', Trans. Linn. Soc., ser. 2 (Zool.), xix, pp. 342, 343, 1933,

including *C. cassidoides* Marsh., and are also clearly visible in carded specimens of *C. tectiformis* Woll. These intercalated rings are incomplete on the lower side of the antenna.

Mouth-parts (fig. 1).—It is evident, from balsam-preparations, that in *C. lobelicola* these structures are normal for *Corylophus*, and correspond in general form with Matthews's figures (Monograph, pl. iv, *D*). The labrum is broader than long, with outline widely curved and slightly produced in the middle in front, several prominent erect hairs on either lateral margin and others on the surface. The mandibles have a comb-like row of fine curved teeth along the inner margin and a curved apical tooth considerably longer than the rest. The maxillae are characteristic of the genus, with the eight remarkable, slender, laminate, translucent processes on the outer apical part of the enlarged second segment*. The labium is shown in fig. 1, V, and is of characteristic form.

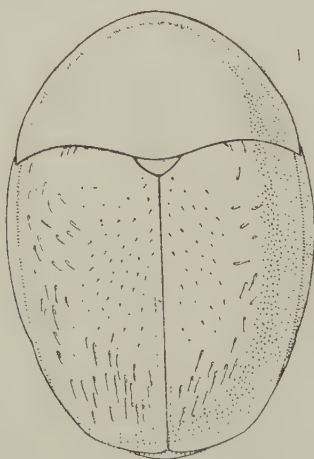


FIG. 2.—*Corylophus lobelicola*.

CORYLOPHUS LOBELICOLA, sp. n. (Figs. 1, 2.)

Obovatus, sat latus ac depressus, supra fortiter nitens et fere glaber; prothorace testaceo, in medio obscuriore, elytris piceo-nigris, suturâ in dimidio anteriore anguste testaceâ; subtus prosterno et mesosterno rufescentibus, metasterno et abdomine piceo-nigris (hoc ad apicem testaceo), epipleuris

* I follow Matthews in calling this large segment of the maxillary palpi the second, though I have been unable to discover clearly, either in the balsam-preparation figured here or in Matthews's own preparations of the maxillae of other species of *Corylophus*, the 'rather small' basal segment described and figured by him in the Monograph. A narrow transverse band of paler chitin, demarcated in fig. 1, IV, by a finely dotted line, may represent a very short basal segment. Similarly, in the labial palpi, I have only clearly discerned two large segments, called by Matthews the second and third. The minute basal segment described and figured by him may be indicated by the lighter, almost unpigmented area, demarcated by a fine dotted line at the base of either palp in fig. 1, V.

pedibusque rufescentibus, femoribus posterioribus obscurioribus, tibiis mediis posterioribusque fere nigris; prothorace fere impunctato; elytris subtilissime haud dense punctulatis, aegre striolatis, marginibus lateralibus (ab humeris usque ad circa $\frac{3}{4}$ longitudinis) sat late explanatis, striâ suturali tenuissimâ ab apice fere ad medium extensâ; alis minutis, fere obsoletis; metasterno et superficie ventrali abdominis minute reticulatis, pilis pallidis, decumbentibus, vestitis. ♂, tibiis anticis ad apicem valde introrsum curvatis. Long. corp., 1.3–1.5 mm.

Obovate, rather broad and depressed, strongly shining and almost glabrous above (only very minute, short hairs, arising from the punctures on the elytra, are visible under a high power); prothorax testaceous, darker in the middle of the disk, where the head shows through the translucent chitin, elytra pitchy-black, narrowly testaceous along the suture in the front half; on the underside the head and prothorax are testaceous, pro- and mesosterna reddish, meta-

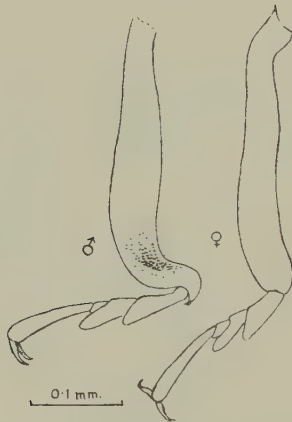


FIG. 3.—*Corylophus lobelicola*, front tibia and tarsus in the two sexes.

sternum and abdomen pitchy-black (the latter testaceous at the apex), antennae with basal segments testaceous and segments 5–9 darker, epipleurae and legs reddish, the hind femora darker, the middle and hind tibiae nearly black. Prothorax nearly impunctate above, only a few, sparse, excessively fine punctures are visible under a high power; elytra with exceedingly fine punctures, not very close, and a faintly striolate appearance in some aspects; metasternum and abdominal sternites with surface minutely reticulate and bearing rather long, pale, decumbent hairs. *Antennae* and *mouth-parts* described above, under the heading of the genus. The *elytra* have a rather wide and conspicuous explanate margin, extending from the shoulder and tapering out at about three-quarters of their length, and a very fine sutural stria, extending forwards from the apex to about the middle. *Hind wings* reduced to minute vestiges (see remarks above, under genus). *Front tibiae* sharply bent inwards at the distal end in the male.

Loc. Uganda ; Ruwenzori, Kigo, 11,000 feet, viii. 1931, two males, three females (*G. L. R. Hancock*) ; shaken from inflorescences of *Lobelia Bequaertii**, together with the numerous specimens of *Orthoperus ruwenzoriensis*, sp. n., and the type-specimen of *Micrambe kigoensis*, sp. n.

This species is about the same size and has the same type of coloration as *C. tectiformis* Woll. (Madeira), with which it also agrees in being flightless. But *C. tectiformis* is much more convex, is more nearly rounded-oval in outline, has the explanate side margins of the elytra narrower, the entire upper surface minutely alutaceous and hence less strongly shining, the prothorax finely but distinctly punctured, and the elytra more closely and a little more strongly punctured. *C. cassidoides* Marsh. (Europe) and *C. japonicus* Matth. also have the same type of coloration (though in *C. cassidoides* the elytra have more or less reddish colouring behind), but are smaller, more convex, different in outline, with more narrowly explanate elytral margins, the elytra more closely and strongly punctured, &c. ; and, in addition, both these species have the hind wings fully developed (as I have satisfied myself by examination of specimens). The only Tropical African species recorded under this genus is *C. usambaranus* Reitter (1908), which, according to the description, is quite different.

ORTHOPERUS Stephens, 1829.

ORTHOPERUS RUWENZORIENSIS, sp. n. (Fig. 3.)

Sat elongato-ovatus, antice sat fortiter angustatus, postice subtruncatus, maximam latitudinem ante medium elytrorum longitudinis attingens ; supra nitens, fortiter alutaceus, omnino glaber ; piceus, interdum obscure brunneus ad latera prothoracis atque ad basin elytrorum, his ad humeros flavescens ; antennarum segmentis 1-4 obscure testaceis, 5-9 piceis ; pedibus obscure brunnescentibus, femoribus mediis et posterioribus, atque tibiarum partibus distalibus, obscurioribus ; prothorace lateribus in dimidio posteriore subrectis, antrorsum convergentibus, in dimidio anteriore introrsum curvatis, marginibus lateralibus tenuiter reflexis, angulis posterioribus fere rectis, superficie tenuissime sat remote punctulatâ ; scutello late subtriangulari, impunctato ; elytris lateribus regulariter arcuatis, apice sat late separatim rotundatis, marginibus lateralibus tenuiter reflexis, striâ suturali nullâ, superficie tenuissime sed densius quam in prothorace punctulatâ ; alis amplissimis ; metasterno et segmento primo abdominis tenuissime sat remote punctulatis, punctulis pilis brevissimis munitis, segmentis ceteris abdominis seriebus submarginalibus pilorum sat longorum munitis ; metasterno et segmento primo striis diver-

* The name given on the labels attached to the specimens of *Corylophus lobelicola*, *Orthoperus ruwenzoriensis*, and *Micrambe kigoensis* obtained by Hancock is *Lobelia Deckenii*. But it has since been decided that this should read '*Lobelia Bequaertii*', now regarded as specifically distinct from *L. Deckenii*. The last-named does not occur on Ruwenzori, but is considered to be confined to Kilimanjaro.

gentibus pone coxas arcuatis; in ♂, metasterno in medio conspicue longitudinaliter impresso, tibiis anterioribus ad apicem dilatatis et incurvatis. Long. corp. 1.25 mm.

Rather elongate-ovate, considerably narrowed in front, subtruncate at the posterior end, with a slight discontinuity in the curve of the outline at the base of the prothorax and elytra, and reaching its greatest breadth a little before the middle of the elytra; shining, quite glabrous, and strongly alutaceous above, pitchy, in some examples with an obscure brownish tinge at the sides of the prothorax and at the base of the elytra, and yellowish-brown at the shoulders; antennae with the four basal segments rather dusky testaceous, segments 5-9 pitchy; legs obscurely brownish, the middle and hind femora, and the apical parts of the tibiae, darker. *Prothorax* with the sides nearly straight, but converging from the base forwards in the basal half, curving inwards anteriorly; lateral margins finely reflexed, hind angles nearly right

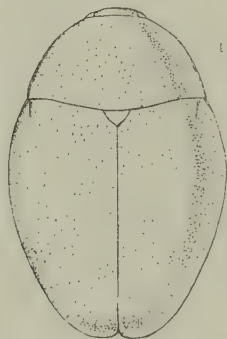


FIG. 4.—*Orthoperus ruwenzoriensis*.

angles, base slightly produced backwards in the middle; surface extremely finely punctured, the distances between the punctures usually equal to several times the diameter of the latter, the punctures themselves appearing under a very high power, in some positions, like minute scratches, a little closer along the base, but not forming a definite basal series. *Scutellum* minute, broadly subtriangular, impunctate. *Elytra* with the sides regularly curved, the posterior ends rather widely separately rounded, and the inner apical angles rounded off; lateral margins finely reflexed, though these are scarcely visible from above; a slight humeral stria, a little oblique in direction, is visible on either side (most of the specimens in which this is clearly marked are male; the stria is almost obsolete in a few, both males and females, but is distinctly visible in some female examples); punctures extremely fine, but considerably closer than on the prothorax; sutural margins narrowly thickened, but there is no sutural stria. *Hind wings* fully developed in both sexes, more than twice the length of the elytron. *Underside*: there are diverging striæ on the

metasternum, curving round behind the middle coxæ and running to the side margins* ; similar striae, though forming a much flatter curve and closer to the coxæ, on the first abdominal segment behind the hind coxæ ; the metasternum and first abdominal segment are rather sparsely and very finely punctured, the punctures bearing very short hairs on the metasternum, rather longer hairs on the first abdominal segment, while the following segments bear submarginal series of rather long, pale hairs. In the male there is a rather conspicuous longitudinal impression in the middle of the metasternum, and the front tibiae are broadened and curved inwards towards the distal end.

Loc. Uganda ; Ruwenzori, Kigo, 11,000 ft., viii. 1931, a long series of both sexes (thirty specimens mounted, and about as many remain in alcohol, *G. L. R. Hancock*) ; they were shaken from inflorescences of *Lobelia Bequaertii*, together with the five examples of *Corylophus lobelicola* and the type-specimen

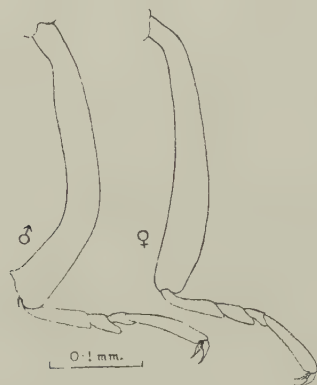


FIG. 5.—*Orthoperus ruwenzoriensis*, front tibia and tarsus in the two sexes.

of *Micrambe kigoensis*, sp. n. Kenya : Mt. Kenya, western slope, from the forest zone between 2,800 and 3,200 metres (c. 9,000 and 10,500 ft.), i. 1912, from *Lobelia bambuseti*, four specimens (*Alluaud et Jeannel*, in Paris Museum).

I described this species from the specimens from Ruwenzori, and the examples from Mt. Kenya were submitted to me later with other material obtained during the expedition of Messieurs Alluaud and Jeannel in British East Africa in 1911 and 1912. The Kenya specimens are, unfortunately, rather damaged, but I can see no characters distinguishing them from those found on Ruwenzori.

Apparently only one species of *Orthoperus* has previously been described

* I called attention to the presence of these striae in a number of species of *Orthoperus*, and figured them in *O. muniae* Scott, Ann. & Mag. Nat. Hist. (8) xix, p. 28, pl. iv, fig. 41 l, 1917.

from Tropical Africa, namely, *O. eichelbaumi* Reitter (1908) from Amani, and this, according to the description, is much smaller than *O. ruwenzoriensis*, not alutaceous and, on the whole, quite different. Among species of which I have seen examples several resemble *O. ruwenzoriensis* in some respects, but none are very close. The European *O. coriaceus* Rey has rather the same shape and is strongly alutaceous, but it is much smaller, and has the punctures on the prothorax and elytra remote and indistinct. The only specimen that I have seen (a cotype) of *O. japonicus* Matth. is about the same size as *O. ruwenzoriensis*, but lighter in colour, more broadly oval, much more shiny, and less alutaceous between the punctures, which are fine, but about as close as in *O. ruwenzoriensis*; *O. japonicus* also has a definite basal prothoracic series of punctures.

Secondary sexual characters.—The curving inwards of the front tibiae towards the apex is a character of the male in several species, as I noted (and also described and figured the front tibiae in both sexes of certain species) in my paper on 'Corylophidae from the Seychelles and Rangoon', Ann. & Mag. Nat. Hist. (8) xix, pp. 1–33, pls. i–v, 1917 (see pp. 29 sqq.). *O. ruwenzoriensis* has, in addition, the marked impression on the metasternum of the male, a character which I have not previously observed.

Cryptophagidae.

Nearly all the representatives of this family belong to two genera, *Mnionomus* and *Micrambe*, both closely related to *Cryptophagus*. Indeed, *Mnionomus* is frequently treated as a subgenus of *Cryptophagus*, and *Micrambe* has been regarded in the same light, though it is usually accorded generic rank. Reasons are given below for restoring full generic status to *Mnionomus*, but it has to be admitted that some African species of *Micrambe* appear to be intergrades between normal *Micrambe* and *Mnionomus*; and the question is raised, whether the species referred to *Mnionomus* may not have originated independently in the Palaearctic and Ethiopian Regions from forms of *Micrambe*, by progressive steps in wing-reduction and shortening of the metasternum, with concomitant divergence from the parent forms in small specific characters such as colour, texture, and sculpture.

While *Micrambe* and *Mnionomus* are well represented by endemic species in the Ethiopian Region, no representative of *Cryptophagus* (s. str.) has yet been recorded from Africa south of the Sahara*. The same remark applies to *Atomaria*, the numerous species of which have all hitherto been recorded from the Palaearctic and/or the Nearctic; but a single species is described below from an altitude of 12,000 feet in Abyssinia.

* I have seen a single specimen (ex Mus. Paris) labelled 'Shoa' and referred by Grouvelle to *Cryptophagus cellaris* Scop., a species widespread in both Palaearctic and Nearctic, but this may well have been introduced into Abyssinia.

MNIONOMUS Wollaston, 1864.

Mnionomus, the author of which was doubtful as to whether it should be accorded full generic rank or treated as a subgenus of *Cryptophagus*, has been generally regarded by later writers as a subgenus, but is here raised to the status of a genus, for reasons explained below.

It was erected to include a single species, discovered in the Canary Islands. Others have since been referred to it, inhabitants of various parts of the Palaearctic Region, but none has previously been described or recorded from Africa south of the Sahara. The Palaearctic species are characterized by flightlessness, the hind wings being rudimentary or absent, and by having the metasternum approximately the same length as the first abdominal segment, instead of much longer; while the hind tarsi, as in *Cryptophagus*, are 4-segmented in the male, 5-segmented in the female.

The nine species described below, from Mt. Chillálo (Abyssinia), Mt. Kenya, Mt. Elgon, Ruwenzori, and the Birunga Mts., conform to the above definition as regards flightlessness and the length of the metasternum. In only three can any vestige of hind wings be found, in the rest these organs are entirely absent in both sexes*. The Abyssinian and three other species also conform to the definition as regards the hind tarsi, which are 4-segmented in the male; but in the other five species the hind tarsi are 5-segmented in both sexes. I have placed them all, however, in *Mnionomus* in spite of this divergence from the typical condition, on account of their close agreement with the Palaearctic species in the other characters mentioned, and the absence of any distinctive feature common to all the African species. On the whole, the characters of *Mnionomus* appear to justify its separation from *Cryptophagus* as a distinct genus, the definition of which must be modified to include species in which the hind tarsi of the male are 5-segmented, as well as species in which they are 4-segmented.

In comparison with *Cryptophagus* some of the Palaearctic species of *Mnionomus* (the genotype, *M. ellipticus* Woll., and *M. baldensis* Er., at any rate) have the callosity on either side of the prothorax, just behind the front angle, much reduced and not produced backwards into a sharp process, and the little tooth at the middle of the side margin of the prothorax also reduced. In the African species this reduction is carried to an extreme, the callosities being entirely absent in four out of the nine described below, while the small teeth at the middle of the side margins are quite wanting in all the species.

The distribution of the Palaearctic species includes, besides the Canary Islands, Central and Southern Europe, the Balearic Islands, Algeria, the Caucasus, and Turkestan†. They are said usually to occur in mountains,

* Another species with vestigial wings is known to me, but I have not described it and have excluded it from these remarks and from the key, because only a single specimen has so far come to hand. I await further material of this, and doubtless other species will be discovered. The unnamed unique specimen is from Mt. Elgon.

† Twenty-one species are enumerated by Schenckling, *Coleopt. Cat.*, Part 76, pp. 46-8, 1923, and at least one has been described since (1924).

in damp dead leaves. The African species described below were discovered at altitudes ranging between 10,800 and 14,400 feet (3,300 and 4,400 metres) on the several groups of mountains. Nearly every species has, so far, been found in association with a single species of plant; three of the species associated with arborescent *Lobelias*, two with an arborescent *Senecio*, two with *Helichrysum* sp., while, in one case (*M. crateris*), no particular plant is specified in the data. The three last are included so that a complete account can be given of the known tropical African species of *Mnionomus*.

Although no species of *Mnionomus* has previously been recorded from Africa south of the Sahara, yet *Micrambe convexa* Grouvelle (Rev. d'Ent. xxvii, pp. 190, 202, 1908), described from Cape Town, is said to have the first abdominal segment as long as the metasternum, and to recall *Mnionomus* in its general form. Grouvelle did not, however, apparently examine the hind wings, as he did not state whether they are fully developed, reduced, or absent. Possibly this species should be referred to *Mnionomus*; in any case it is evidently quite distinct from those described below.

Mesosternum.—I have found a useful specific character in the form of what is here termed the 'median area' of the mesosternum. The anterior end of this area receives the apex of the intercoxal process of the prosternum into a more or less hollow surface when the prothorax is retracted ventrally, while the posterior part of the median area extends back between the middle coxae to meet the front margin of the metasternum. The median area is separated at the sides (in front of the middle coxae) by more or less raised ridges from the lateral wings of the mesosternum, which extend laterally on either side, in front of the coxal cavities, to the sutures separating the mesosternum from its episterna.

Antennae.—These are described under *M. rhynchopetali* and *M. hancocki*. They are not mentioned under the other species, as no very striking specific differences have been observed.

Aedeagus.—Examples of several species of *Mnionomus* and *Micrambe* were dissected and the aedeagus extracted, this procedure being indispensable for the determination of the sex in those species in which the posterior tarsi have the same number of segments in both sexes, and no external sexual characters exist. Usually the aedeagus has been gummed on the card beside the insect, but in the case of *Mnionomus hancocki* the aedeagus of four specimens was mounted in balsam. In general pattern this organ closely resembles that of *Antherophagus nigricornis* F., the only representative of Cryptophagidae dealt with by Sharp and Muir ('The Comparative Anatomy of the Male Genital Tube in Coleoptera', Trans. Ent. Soc. London, 1912, p. 522, pl. lix, fig. 105). The internal sac was not investigated in detail by Sharp and Muir; in *Mnionomus hancocki* the sac (invaginated in the preparations) exhibits some interesting structural features. Differences between some species are also apparent in the chitinous parts of the aedeagus, though it has not at present proved necessary to use these characters for distinguishing the species.

KEY TO THE TROPICAL AFRICAN SPECIES OF MNIONOMUS.

The following key indicates that certain of the anatomical characters discussed above occur among the several species in what appears to be a haphazard manner. Thus, species in which the tarsi are heteromerous in the male sex, and species in which they are not so, fall into both the principal divisions of the key—that in which some degree of callosity is still found at the front angles of the prothorax and that in which there is none. Also, the species in which vestiges of the hind wings remain are not marked off by any other visible character of major importance from the species in which there are no traces of these organs; they are only separated by a combination of small specific characters. It is, therefore, difficult to assess the morphological and phylogenetic value of the characters used. There is, however, no doubt about the distinctness of the species, when the small specific differences are considered as a whole in each case:—

A. Prothorax without any small tooth at the middle of the sides, but with callosities at the front angles.

a. Hind wings present, but vestigial.

aa. Posterior tarsi 5-segmented in both sexes. Prothorax about $1\frac{1}{3}$ as broad as long, callosities slight, elongate, obliquely truncate. Mesosternum with median area longer than broad, concave, with sides elevated and convergent behind, and posterior margin slightly sinuate. Dark brown, dull, minutely reticulate between the punctures. Length 2.3–2.4 mm.

[(Mt. Kenya).

M. alluaudi, sp. n.

aa¹. Posterior tarsi 4-segmented in male.

aaa. Prothorax strongly transverse, about $1\frac{1}{3}$ as broad as long, much narrower at base than at hind end of callosities, the latter large and thick, base with a short longitudinal keel extending forwards from the middle. Mesosternum with median area long and narrow, with sides elevated and converging, and hind end truncate. Colour variable, mainly blackish, surface of elytra shining, that of prothorax duller and reticulate. Length about 2.5 mm.

[(West Ruwenzori).

M. burgeoni, sp. n.

aaa¹. Prothorax less transverse, over $1\frac{1}{3}$ as broad as long, little narrower at base than at hind end of callosities, the latter shorter and less thick, base with only a very short and slight median longitudinal keel. Mesosternum with sides of median area slightly curved, less convergent behind. Colour dark brown or blackish, base of elytra more or less fulvous, surface rather dull, that of head and prothorax minutely reticulate, that of elytra extremely finely punctulate, between the punctures. Length about 2.3 mm,

[(Mt. Elgon).

M. crateris, sp. n.

*a*¹. Hind wings entirely absent.

aa. Posterior tarsi 4-segmented in male. Prothorax about $1\frac{1}{4}$ broader than long, callosities slight, elongate, obliquely truncate. Mesosternum with median area long and narrow, concave, with sides nearly parallel, but curving in at the posterior end. Dark brown, surface dull, but not reticulate. Length 2.1-2.2 mm.

[(Mt. Elgon).

M. johnstoni, sp. n.

*aa*¹. Posterior tarsi 5-segmented in both sexes. Prothorax nearly $1\frac{1}{4}$ as broad as long; callosities slight, elongate, curved, not truncate. Mesosternum with median area rather narrow, strongly concave, with sides elevated, slightly curved, convergent behind, and posterior margin excised. Colour variable, usually elytra dark brown and prothorax fulvous; surface moderately shining. Length nearly 2.3 mm.

[(Mt. Elgon).

M. helichrysi, sp. n.

B. Prothorax with neither a small tooth at the middle of the sides, nor any callosity at the front angles. Hind wings entirely absent in all known species.

b. Posterior tarsi 4-segmented in male. Prothorax more than $1\frac{1}{2}$ as broad as long, with a deep foveole on either side at base. Mesosternum with median area about as broad as long, with sharply elevated sides, slightly convergent behind, and posterior margin sub truncate. Reddish-fulvous, smooth, shining. Length about 2.5 mm.

[Abyssinia).

[(Mt. Chillálo,

M. rhynchopetali, sp. n.

*b*¹. Posterior tarsi 5-segmented in both sexes.

bb. Smaller, 2.4-2.5 mm. Prothorax only about $1\frac{1}{6}$ as broad as long, foveolate on either side at base. Mesosternum with median area broad, concave, with sides elevated and nearly parallel, posterior margin truncate. Dark fulvous or dark brown, shining

[(Mt. Kenya).

M. jeanneli, sp. n.

*bb*¹. The largest species known, length 3-4 mm. (abnormally small specimens just under 3 mm.). Prothorax very broad, about $1\frac{1}{3}$ as broad as long. Mesosternum with median area long and narrow, slightly concave, sides nearly parallel, not sharply elevated. Dark brown, subopaque

[(Ruwenzori).

M. hancocki, sp. n.

*bb*². Length about 3 mm. Prothorax about $1\frac{1}{6}$ as broad as long. Mesosternum with median area nearly flat, narrowing to the truncate posterior end. The lightest-coloured species, yellowish

[(Birunga Mts.).

M. gibbinsi, sp. n.

MNIONOMUS ALLUAUDI, sp. n. (Fig. 6.)

Obscure brunneus, pedibus antennisque testaceis, harum clavis parum infuscatis, opacus, superficie inter puncta minutissime reticulatâ, pilis curtis, pallidis, decumbentibus (in elytris, aliquibus erectis) vestitus; prothorace valde transverso, circa $1\frac{1}{3}$ latiore quam longiore, angulis anterioribus longe truncato-callosis, postice haud denticulatis, lateribus in parte mediâ fere parallelis, vix sinuatis, deinde ad angulos posteriores convergentibus, his argutis sed multo magis quam rectis, lateribus et basi tenuiter marginatis,

superficie modice fortiter sat dense punctatâ; scutello valde transverso, postice subtruncato, marginibus declivibus; elytris subtiliter sat dense granulato-punctatis, lateribus gradatim curvatis; alis minutis, vestigialibus; mesosterno areâ mediâ concavâ, lateribus elevatis, postice parum convergentibus, margine posteriore parum sinuato; metasterno et abdomine modice fortiter sat dense punctatis; tarsis posterioribus in ♂ et in ♀ 5-segmentatis. Long. corp. c. 2.3-2.4 mm.

Almost uniformly very dark brown, in some specimens the extreme base of the elytra and front and side parts of the prothorax have a dull reddish tinge; legs and antennae testaceous, clubs of the latter slightly infuscated; surface dull, minutely reticulate between the punctures, covered with short, pale,

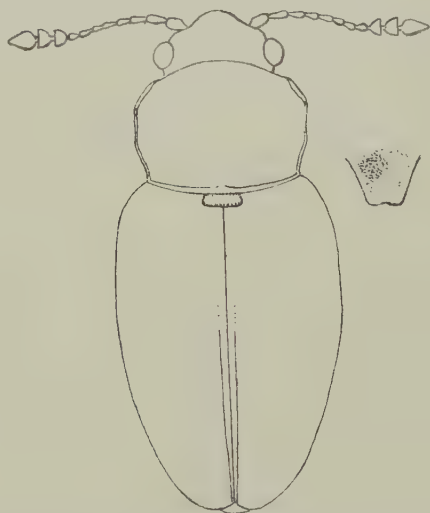


FIG. 6.—*Mnionomus alluaudi*, $\times 30$, and median area of mesosternum, $\times 70$.

decumbent hairs. *Head* closely punctured. *Prothorax* strongly transverse, about $1\frac{1}{3}$ times as broad as long; front angles callose and obliquely truncate, the callosities, seen in side view, elongate, but not denticulate at the posterior end; behind the callosities the sides are nearly parallel and very slightly sinuate for a space, then convergent to the hind angles, which are definite, but much wider than right angles; sides and base finely margined, but no foveae in front of the base; surface faintly impressed on either side of the middle line in the posterior half, closely and moderately strongly punctured. *Scutellum* very short and transverse, almost truncate behind, with margins declivous, so that it appears to be delimited by a deep channel. *Elytra* with sides gradually curved throughout their length, their combined greatest breadth being about $\frac{1}{3}$ greater than that of the prothorax, separately rounded at the

apices, each with a fine sutural stria becoming obsolete towards the base, and with a faint oblique impression a little behind the base, with fine and close granular puncturation, and some short erect hairs among the decumbent hairs, especially noticeable on the sides and towards the apex. *Hind wings* vestigial, narrow and minute, about $\frac{1}{2}$ the length of the elytra. *Mesosternum* closely and coarsely punctured, the median area longer than broad, concave, with sides elevated and convergent behind, its hind margin slightly sinuate. *Metasternum* and *abdominal segments* moderately strongly and closely punctured. *Posterior tarsi* 5-segmented in both sexes.

Loc. Mt. Kenya, western slope, alpine zone; station 43, 3,300–3,500 metres (c. 10,800–11,500 ft.), i–ii. 1912, two examples; station 45, 4,000–4,100 metres (c. 13,100–13,500 ft.), ii. 1912, five examples; station 46, 4,300–4,400 metres (c. 14,100–14,400 ft.), ii. 1912, two examples (*Alluaud* and *Jeannel*); the two specimens last named are labelled no. 177, indicating that they were taken from *Senecio keniodendron*.

Although this species has callosities at the front angles of the prothorax, it does not closely resemble any of the Palaearctic species which I have seen, differing from them in lacking the little tooth in the middle of the sides of the prothorax and in other respects.

MNIONOMUS BURGEONI, sp. n. (Fig. 7.)

Colore sat variabilis, nigricans, prothorace ad margines elytrisque ad latera et ad apices obscure fulvescentibus (in exemplis nonnullis fere flavis), antennis pedibusque obscure ferrugineis; nitidus, prothorace parum opacior, pilis pallidis decumbentibus (in elytris aliquibus erectis) vestitus; prothorace valde transverso, circa $1\frac{1}{3}$ latiore quam longiore, angulis anterioribus crasse truncato-callosis, postice haud denticulatis, lateribus in parte mediâ vix convergentibus, deinde magis convergentibus et leviter sinuatis ad angulos posteriores, his argutis sed magis quam rectis, lateribus tenuiter, basi crassius, marginatis, basi vix foveolatâ, carinâ brevi longitudinali mediâ munitâ, superficie sat fortiter punctatâ; scutello valde transverso, postice subtruncato, marginibus declivibus; elytris prothorace circa $\frac{1}{4}$ latioribus, pone basin vage oblique impressis, superficie sat fortiter punctatâ, ad basin in ♀ rugosâ; alis vestigialibus; mesosterno areâ mediâ angustâ, lateribus elevatis, ad marginem posteriorem truncatum convergentibus; tarsis posterioribus in ♂ 4-, in ♀ 5-segmentatis. Long. corp. c. 2.5 mm.

Colour rather variable, blackish, with the marginal parts of the prothorax and lateral and apical parts of the elytra usually more or less dark tawny; in some specimens the tawny colour is lighter, almost yellow, especially on the prothorax; legs and antennae dark ferruginous; surface of elytra shining, that of prothorax a little duller and minutely reticulate between the punctures; the pale decumbent pubescence is rather longer than in some species (e.g. *M. alluaudi*), with some erect hairs on the elytra. *Head* closely punctured,

Prothorax strongly transverse, its greatest breadth about $1\frac{1}{3}$ times the length ; front angles truncate-callose, the callosities slightly upturned, and, seen in side view, thick, not denticulate at the hind end, with a large puncture in the middle of the truncate surface ; for a short distance behind the callosities the sides are slightly convergent, then they bend inwards, converging more strongly and slightly sinuate (also minutely but irregularly crenulate or denticulate) to the hind angles, which are definite but wider than right angles ; sides finely, base more thickly, margined, with only faint traces of foveoles on either side in front of the base, and a median longitudinal keel running

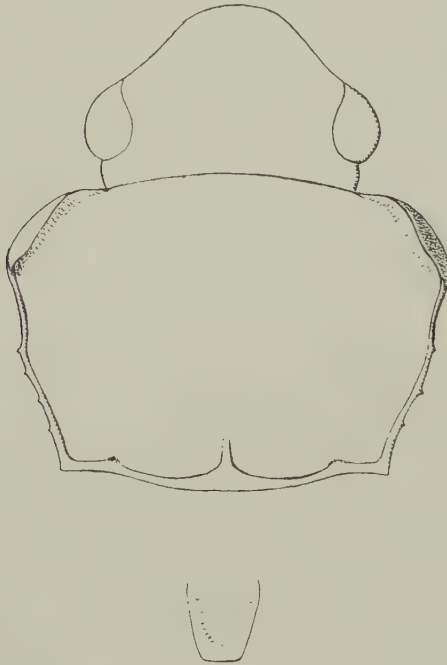


FIG. 7.—*Mnionomus burgeoni*, head and prothorax, and median area of mesosternum, all $\times 70$.

forwards a short distance from the middle of the base ; surface rather strongly punctured, the interspaces usually greater than the diameter of the punctures. *Scutellum* very short and transverse, subtruncate behind, with margins declivous. *Elytra* with sides gradually curved, tapering considerably behind the middle, separated at the apex and with apices rounded, their combined greatest breadth roughly $\frac{1}{4}$ greater than that of the prothorax, each with a fine sutural stria becoming obsolete towards the base, and with a vague oblique impression a little behind the base ; the puncturation is about as strong as that on the

prothorax, the interspaces mostly considerably wider than the diameter of the punctures, and the surface of the basal part is rugose in the female. *Hind wings* vestigial, a little over $\frac{1}{5}$ the length of the elytra, rather broad and blunt-ended. *Mesosternum* with median area long and narrow, its sides elevated and converging to the truncate hind end. *Metasternum* and *first abdominal segment* rather finely and not very closely punctured, the posterior segments more finely and closely. *Posterior tarsi* 4-segmented in male, 5-segmented in female.

Loc. Uganda: Ruwenzori, Bujuku Valley, 10,800 ft., 8. viii. 1933, one male (type), from seed-stalk of *Lobelia Bequaertii* (W. J. Eggeling). Belgian Congo: West Ruwenzori, at head of River Nyamuamba, 4,200 metres (nearly 13,800 ft.), vii. 1932, thirty-one examples (*L. Burgeon*); unfortunately no record was kept as to whether these latter were collected from *Lobelia Wollastonii*, *Senecio erioneuron*, or *Helichrysum* sp.

This species has the prothoracic callosities thicker and more definitely truncate than either *M. alluaudi* or *M. johnstoni* or *M. helichrysi*. Like those species, it differs from the Palaearctic members of the genus in lacking the little tooth in the middle of the sides of the prothorax. It differs in many ways from *M. alluaudi*; *inter alia*, the vestigial wings are broader and blunter in *M. burgeoni*, which also has the posterior tarsi 4-segmented in the male.

MNIONOMUS JOHNSTONI, sp. n. (Fig. 8, d.)

Obscure brunneus, elytris ad suturam et ad basin plus minusve fulvis, prothorace interdum antice parum rufescente, antennis pedibusque fulvis; sat opacus, pilis pallidis, curtis, decumbentibus (in elytris, aliquibus erectis) vestitus; prothorace transverso, circa $1\frac{1}{4}$ latiore quam longiore, angulis anterioribus tenuiter longe truncato-callosis, postice haud denticulatis, lateribus in parte mediâ fere parallelis, vix sinuatis, deinde ad angulos posteriores parum sinuatis et sat fortiter convergentibus, his argutis sed multo magis quam rectis, lateribus et basi tenuiter marginatis, hac utrinque vix foveolatâ, superficie (cum capite) dense fortiter punctatâ; scutello brevissimo, valde transverso, postice subtruncato et super elytra elevato; elytris sat dense, sed distincte subtilius quam in prothorace, granulato-punctatis, lateribus gradatim curvatis; alis nullis; mesosterno areâ mediâ sat angustâ, concavâ, lateribus de basi divergentibus, postice curvatis, angulis posterioribus rotundatis; metasterno et segmentis abdominis fortiter, pariter dense, punctatis; tarsis posterioribus in ♂ 4-, in ♀ 5-segmentatis. Long. corp. 2.1-2.2 mm.

Very dark brown, in most specimens the elytra are more or less fulvous along the suture and at the base and the prothorax is slightly reddish in front; antennae and legs fulvous; surface rather dull, covered with pale, short, decumbent hairs, and with a few very short erect hairs on the elytra. *Head* and *prothorax* strongly and densely punctured, the punctures less than their own diameter apart; *prothorax* transverse, its greatest breadth about $1\frac{1}{4}$ times the length, its front angles with a slight elongate callosity, which tapers before

and behind, and has a large puncture in the middle of its truncate surface ; there is no denticulation at the posterior end of the callosities or in the middle of the sides, the latter are nearly parallel and faintly sinuate for a space behind the callosities, then distinctly sinuate and rather strongly convergent to the hind angles, which are definite, but much wider than right angles ; sides and base margined, and there is a slight impression (scarcely a foveole) on either side at the base. *Scutellum* very short and transverse, subtruncate behind, and raised above the surface of the elytra at the sides and behind. *Elytra* reaching their greatest breadth before the middle of the length, with sides gradually curved throughout their length, apices rather bluntly and separately curved, the fine sutural striae obsolete in nearly the anterior half of the length, the surface closely punctured, more finely than the prothorax, and the puncturation having a granulate appearance. *Hind wings* entirely absent. *Mesosternum* closely and strongly punctured, the median area concave, rather long and narrow, with sides diverging from the base, curved posteriorly, with hind angles rounded off. *Metasternum* and *abdominal segments* strongly and about equally closely punctured. *Posterior tarsi* 4-segmented in male, 5-segmented in female.

Loc. Uganda : Mt. Elgon, 11,000 ft., 5. iii. 1934, on flowers of *Helichrysum* sp., six specimens (*H. B. Johnston*).

The specimens, as received, were among a large number of specimens of *Meligethes*, in company with which they were probably taken.

This species is dedicated to its discoverer, who, while stationed temporarily at Kampala in connexion with locust investigation work under the Imperial Institute of Entomology, made a brief visit to Mt. Elgon.

Superficially this species resembles *M. alluaudi*, but it is slightly smaller and usually has the fulvous colour along the suture of the elytra ; the prothorax is longer in proportion to its breadth, and is more strongly punctured ; the median area of the mesosternum is different in shape, and there are other differences in puncturation &c. In less superficial characters the two species are very distinct, since in *M. alluaudi* the hind wings are present, though vestigial, and the hind tarsi are 5-segmented in both sexes.

MNIONOMUS CRATERIS, sp. n. (Fig. 8, *e*.)

Obscure brunneus vel nigrescens, elytris ad basin plus minusve fulvis, antennis pedibusque fulvis, antennarum clavis et parte distali tibiarum obscurioribus ; sat opacus, capite prothoraceque dense et fortiter punctatis, superficie inter puncta minute reticulatâ, elytris subtilius punctatis, superficie inter puncta minutissime et subtilissime punctulatâ ; prothorace magis quam $1\frac{1}{5}$ latiore quam longiore, angulis anterioribus breviter truncato-callosis, lateribus in parte mediâ fere parallelis, sinuatis, deinde ad angulos posteriores convergentibus, lateribus tenuiter, basi crassius, marginatis, hac utrinque haud foveolatâ ; alis vestigialibus, minutis, angustis ; mesosterno areâ mediâ

sat angustâ, concavâ, lateribus parum curvatis, margine posteriore truncato ; tarsis posterioribus in ♂ 4-, in ♀ 5-segmentatis. Long. corp. c. 2.3 mm.

Superficially this species resembles *M. johnstoni* (which also occurs on Mt. Elgon), but it is distinguished by possessing vestigial hind wings ; these have been examined in several specimens, and are minute and narrow (like those of *M. alluaudi*). The prothorax also is a different shape ; the proportions of length to greatest breadth are nearly the same, between $1\frac{1}{2}$ and $1\frac{1}{4}$ times as broad as long, but the sinuation of the sides in the middle part, immediately behind the callosities, is a little more marked, and the sides are considerably less convergent in front of the hind angles ; the truncate surface of the callosities, seen from the side, is smaller and less elongate. The surface is rather dull,

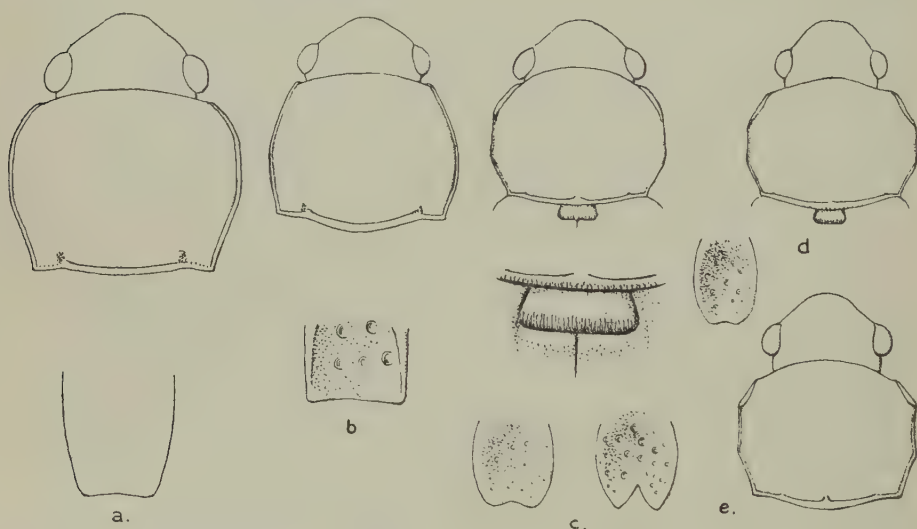


FIG. 8.—a, *Mnionomus gibbinsi*, outline of prothorax $\times 30$, and median area of mesosternum $\times 70$; b, *M. jeanneli*, prothorax $\times 30$, median area of mesosternum $\times 70$; c, *M. helichrysi*, prothorax and scutellum $\times 30$, scutellum, enlarged, to indicate the steeply sloping margins, median area of mesosternum in a male (left) and in a female specimen $\times 70$; d, *M. johnstoni*, prothorax and scutellum $\times 30$, median area of mesosternum $\times 70$; e, *M. crateris*, prothorax $\times 30$.

that of the head and prothorax being minutely reticulate in the interspaces of the close and strong puncturation, while on the elytra the punctures are finer, and the interspaces extremely minutely and finely punctulate ; this last character has not been observed in any other species, and requires a high power (magnification of about 50 diameters or upwards) for its discernment.

Colour dark brown or blackish, usually with more or less fulvous at the base of the elytra and (in some specimens) along the suture ; antennae and legs fulvous, clubs of the former and distal parts of the latter darker. The median

area of the mesosternum has nearly the same form as in *M. johnstoni*. The prothorax has its sides finely, and base more thickly, margined, the base not foveolate on either side, and with a median longitudinal keel just indicated, but shorter and less marked than in *M. burgeoni*. Hind tarsi 4-segmented in male, 5-segmented in female.

Loc. Kenya: crater of Mt. Elgon, foot of Koitobbos Peak, 4,000 metres (about 13,100 ft.), ten examples (Mission de l'Omo, 1932-3). These specimens are not labelled as having been found in association with any particular plant, but the locality is described as a moorland with a dense growth of *Alchemilla* and with giant *Senecios* and *Lobelias*, and it is stated that insects were collected under dead *Senecios* and under *Lobelias* ('Liste des Stations' of the Mission de l'Omo, p. 3, 1933). It is highly probable that *M. crateris* is associated with one or more of these plants. According to the table of altitudinal range of the Giant *Lobelias* (Kew Bulletin, ii, p. 69, 1934), the species found at 13,000 ft. on Mt. Elgon are *Lobelia Telekii* and *L. elgonensis*.

MNIONOMUS HELICHRYSI, sp. n. (Fig. 8, c.)

Colore variabilis, plerumque elytris obscure brunneis et prothorace fulvo, sed interdum omnino fulvus vel omnino obscurus, fere piceus; modice nitidus, pilis curtis, pallidis, decumbentibus (in elytris, aliquibus erectis) vestitus; prothorace transverso, fere $1\frac{1}{4}$ latiore quam longiore, angulis anterioribus longe arcuato-callosis (margine superiore tenuiter reflexo), postice haud denticulatis, lateribus in parte mediâ fere rectis et parallelis, deinde ad angulos posteriores sat abrupte constrictis, his argutis sed latioribus, lateribus et basi marginatis, superficie (cum capite) modice fortiter et dense punctatâ; scutello brevissimo, valde transverso, postice subtruncato et super aream proximam elytrorum conspicue elevato; elytris lateribus gradatim haud fortiter curvatis, superficie subtilius et paulum minus dense quam in prothorace punctatâ, ad basin parum granulatâ et vage depressâ; alis nullis; mesosterno areâ mediâ valde concavâ, lateribus elevatis paulum curvatis et postice convergentibus, margine posteriore exciso vel breviter fisso; metasterno margine posteriore in medio breviter fisso, hoc et segmento basali abdominis sat fortiter punctatis; tarsis posterioribus in utroque sexu 5-segmentatis. Long. corp. fere 2.3 mm.

Variable in colour, usually the elytra are dark brown (sometimes with more or less fulvous along the suture and at the base), while the prothorax is fulvous and the head may be either fulvous or dark, but a few specimens are almost entirely fulvous and some entirely dark, almost pitchy; antennae and legs fulvous; moderately shining, covered with pale, short, decumbent hairs, and with a few short erect hairs on the elytra. Head and prothorax moderately strongly and closely punctured, the punctures sometimes more than their own diameter apart; prothorax transverse, nearly $1\frac{1}{4}$ times as broad as long, front angles callous, the callosity with its upper margin finely reflexed, its surface not truncate but curved, and tapering in front and behind, with no trace of denticulation at the posterior end; sides nearly straight and parallel for

a space behind the callosities, then rather abruptly and strongly constricted (and faintly sinuate) to the hind angles, which are definite but very wide; sides and base margined. *Scutellum* very short and transverse, subtruncate behind, with the downward slope of the surface of the elytra round its sides and hind margin carried to an extreme, so that a deep and wide impression is formed round the scutellum. *Elytra* reaching their greatest width at about the middle of the length, sides forming a gradual, rather flattened, curve, posterior ends rather wide and blunt, slightly separated; the fine sutural striae become obsolete in front at a variable distance, sometimes about $\frac{1}{3}$ the length of the elytron, from the base; surface more finely and a little less closely punctured than that of the prothorax, with a rough or granular appearance due to unevenness in the basal part of the elytron, where also the surface is vaguely depressed. *Hind wings* quite absent. *Mesosternum* with median area rather narrow, strongly concave, its slightly elevated sides a little curved and convergent to the posterior end, its hind margin excised, in some specimens with a short mid-longitudinal cleft. *Metasternum* also with a short median longitudinal cleft in the hind margin, in some specimens prolonged forwards as a short furrow*; metasternum and *first abdominal segment* rather strongly punctured, but the punctures are a little more than their own diameter apart; the remaining abdominal segments more finely punctured. *Posterior tarsi* 5-segmented in both sexes.

Loc. Uganda: Mt. Elgon, 11,000 ft., iii. 1934, on flowers of *Helichrysum* sp., twenty-nine specimens (*H. B. Johnston*). Though taken at the same altitude as the examples of *M. johnstoni*, the specimens of *M. helichrysi* were apparently collected separately.

M. helichrysi is distinguished from *M. johnstoni* by its slightly larger size, different (though variable) coloration (the fulvous prothorax usually contrasting with the darker elytra), more shining surface and less dense puncturation; the prothorax is a little longer in proportion to its width, the callosities at the front angles are less truncated; the impression round the sides and hind margin of the scutellum is even more marked; the median area of the mesosternum is differently shaped, with the hind margin distinctly excised, and the fissure in the hind margin of the metasternum is more conspicuous; and, finally, the tarsi are not heteromorous in the male.

MNIONOMUS RHYNCHOPETALI, sp. n. (Fig. 9.)

'*Cryptophagus* (subgenus *Mnionomus*) sp.', Scott, Journ. Linn. Soc. xxxvii, p. 564, 1931.

Rufo-fulvus, laevis, nitidus, pilis curtis, pallidis, decumbentibus vestitus;

* Two of the specimens exhibiting the posterior mid-longitudinal fissure of the mesosternum, and the forward continuation of the posterior median cleft in the metasternum as a furrow, have been shown by dissection to be females. It is, therefore, possible that these slight differences are in the nature of secondary sexual characters.

capite dense subtiliter punctato; prothorace magis quam $1\frac{1}{4}$ latiore quam longiore, ad angulos anteriores quam basi parum angustiore, lateribus late arcuatis, his et basi marginatis, marginibus lateralibus antice nullo modo callosis, vix bisinuatis, angulis anterioribus rotundatis, posterioribus argutis, margine basali utrinque antrorsum flexo et foveolato, superficie convexâ, ad basin sat fortiter declivi, subtiliter minus dense punctatâ; scutello transverso; elytris maximam latitudinem circa $\frac{1}{3}$ longitudinis attingentibus, postice gradatim angustatis, apice separatim obtuse rotundatis, sparse subtiliter haud dense punctatis, striâ suturali tenui, antice obsoletâ; alis nullis; mesosterno areâ mediâ sat latâ, concavâ, utrinque margine sat fortiter elevatâ munito; tarsis posterioribus in ♂ 4-, in ♀ 5-segmentatis. Long. corp. c. 2.5 mm.

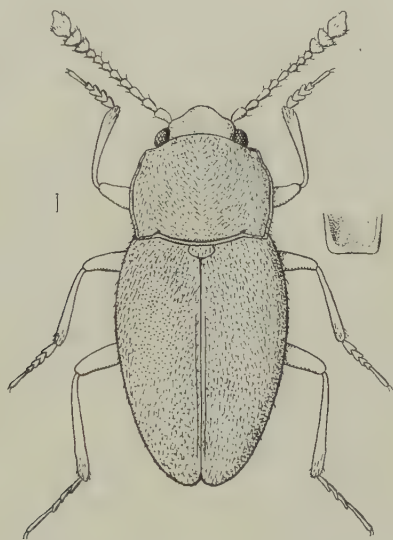


FIG. 9.—*Mnionomus rhynchopetali*, male, and median area of mesosternum more highly magnified.

Reddish-fulvous, with the clubs of the antennae not darkened; in some specimens the lateral parts of the elytra appear darker, or the darker shade may spread right across the middle part of the elytra; smooth and shining, covered with short, pale, decumbent hairs. *Antennae* rather stout, with basal segment incrassate, second about the same length but narrower, about $1\frac{1}{2}$ times as long as broad, third longer, nearly twice as long as broad, fourth shorter than second or third, fifth slightly longer than fourth, sixth and seventh short, subequal, only a very little longer than broad, eighth still shorter and almost circular in outline; ninth to eleventh forming the club, ninth and tenth strongly transverse, eleventh considerably shorter than the two preceding taken together. *Head* finely and closely punctured, the punctures separated

by spaces often equal to little more than their own diameter. *Prothorax* over $1\frac{1}{4}$ times as broad as long, a little narrower at the front than at the hind angles, broadly arcuate at the sides; sides and base margined; viewed from above, the front angles are rounded off, the hind angles definite but wider than right angles; there is no callosity or oblique truncation behind the front angles, the lateral margin is continuous throughout, but slightly sinuate a little behind the front angles, and again, even more slightly, at about the middle of its length; the basal margin is bent rather sharply forwards on either side, less than half the distance from the hind angle to the scutellum, and there is a deep punctiform impression just in front of the bend in the margin; surface rather convex, sloping considerably to the hind margin, finely and not very closely punctured, the punctures separated by spaces usually greater than their own diameter. *Scutellum* transverse. *Elytra* broader than, and a little over twice the length of, the prothorax, with sides curved, attaining their greatest breadth at about $\frac{1}{3}$ of their length from the base, then narrowing gradually, with apices separate and bluntly rounded; each elytron has a fine sutural stria, obsolete towards the base; with scattered, fine but not close, punctures, the surface interspaces equal to several times the diameter of the punctures. *Hind wings* absent. *Mesosternum* with median area about as broad as long, subtruncate behind, concave, with sharply elevated ridges at the sides, converging slightly to the posterior end. *Metasternum* and *first abdominal segment* not very closely punctured, the remaining abdominal segments more closely punctured. *Posterior tarsi* 4-segmented in the male, 5-segmented in the female.

Loc. Abyssinia: summit of Mt. Chillálo, c. 12,000 ft., 18 & 21. xi. 1926, in wet decaying substance under the loose bark of dead stems of *Lobelia Rhynchopetalum*, thirty-seven examples (*Scott*).

MNIONOMUS JEANNELI, sp. n. (Fig. 8, b.)

Cryptophagus jeanneli Grouvelle, MS. name.

Obscure brunneus, elytrorum suturâ et interdum capite prothoraceque fulvescentibus, vel omnino obscure fulvus; nitidus, pilis pallidis, curtis, decumbentibus vestitus; prothorace circa $1\frac{1}{6}$ latiore quam longiore, ad angulos anteriores quam basi aliquanto angustiore, lateribus ad angulos anteriores nullo modo callosis, arcuatis, ante angulos posteriores vix sinuatis, angulis anterioribus obtusis, posterioribus argutis, basi utrinque foveolato, striâ marginali utrinque ad angulum posteriorem extensâ, superficie ad angulos posteriores explanatâ, modice fortiter sat dense punctatâ; scutello valde transverso, margine posteriore declivi; elytris maximam latitudinem ante medium attingentibus, sat tenuiter punctatis, superficie ad basin vage oblique impressâ et rugulosâ; alis nullis; mesosterno areâ mediâ sat latâ, concavâ, crasse punctatâ, postice truncatâ, lateribus elevatis; metasterno antice in medio parum impressâ, sat fortiter et dense punctato; segmentis ventralibus

abdominis subtiliter punctatis ; tarsi posterioribus in ♂ et in ♀ 5-segmentatis. Long. corp. 2.4–2.5 mm.

Dark fulvous or dark brown ; some specimens are entirely dark brown except along the suture of the elytra, which is fulvous, in others the head and prothorax are also fulvous, leaving the middle and lateral parts of the elytra dark, while others are entirely fulvous ; legs and antennae fulvous, clubs of the latter not darkened ; surface shining, covered with short, pale, decumbent hairs. *Head* rather sparsely punctured. *Prothorax* usually about $1\frac{1}{2}$ times (or a little more) as broad as long, considerably narrower at the front than at the hind angles ; sides with no trace of callosity in front, finely margined, arcuate, considerably narrowed to the front angles, which are obtuse, very slightly sinuate before the hind angles, which are definite, slightly wider than right angles ; base margined, with a punctiform impression on either side, and the marginal channel continued to the hind angles ; surface explanate near the hind angles, moderately strongly and fairly closely punctured. *Scutellum* strongly transverse, declivous towards its hind margin, close to which the surface of the elytra also slopes down, so that a channel is formed round the hind margin of the scutellum. *Elytra* reaching their greatest breadth before the middle of the length, about $\frac{1}{2}$ broader than the prothorax, then narrowing gradually, apices separate and bluntly rounded ; viewed from above a finely reflexed lateral margin is visible just behind the shoulders ; the fine sutural striae become obsolete at the base ; punctures rather fine, scattered, not very close ; surface with a trace of rugulosity, specially marked in the vaguely impressed part within and behind the shoulders, which under a high power presents minute transverse rugae between the punctures. *Hind wings* entirely absent in both sexes. *Mesosternum* with median area broad, concave, coarsely punctured, truncate behind, with sides elevated and nearly parallel. *Metasternum* slightly impressed in the middle in front, strongly and closely punctured. *Ventral abdominal segments* very finely punctured, in contrast to the metasternum. *Posterior tarsi* 5-segmented in both sexes.

Loc. Mt. Kenya, western slope, alpine zone ; station 44, 3,500–3,700 metres (c. 11,500–12,100 ft.), i. 1912, twenty-three examples, and station 46, 4,300–4,400 metres (c. 14,100–14,400 ft.), ii. 1912, two examples (*Alluaud and Jeannel*) ; all the specimens were taken from giant *Senecios*, *Senecio keniodendron*, in some cases by sifting detritus from the covering of dead leaves.

Apart from having the posterior tarsi 5-segmented in the male, this species somewhat resembles *M. rhynchopetali* in general appearance ; it is, however, generally darker, and distinguished by the much less transverse prothorax and the surface of the latter being much more strongly punctured and more or less explanate near the hind angles, by the vague oblique impression on the basal part of each elytron, the slight rugulosity of the elytra, the strong and close puncturation of the metasternum and slight anterior impression on the latter, &c.

Mnionomus hancocki, sp. n. (Fig. 10.)

Obscure brunneus, antennis pedibusque ferrugineis, subopacus, pilis flavescensatibus sat longis decumbentibus dense vestitus, his in parte posteriore elytrorum interdum erectis; antennis sat robustis; capite dense sat subtiliter punctato; prothorace circa $1\frac{1}{3}$ latiore quam longiore, antice et postice sat fortiter angustato, ad angulos anteriores quam basi parum angustiore, lateribus late arcuatis, ad angulos posteriores vix sinuatis, tenuissime marginatis, ad angulos anteriores nullo modo callosis, angulis anterioribus rotundatis,

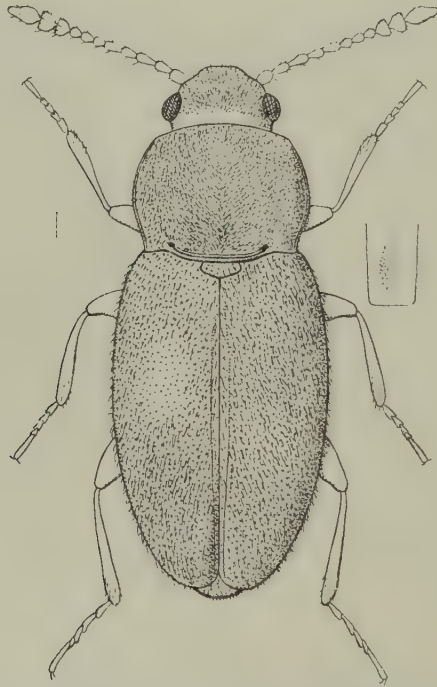


FIG. 10.—*Mnionomus hancocki*, and median area of mesosternum more highly magnified.

posterioribus argutis, margine basali utrinque antrorsum flexo, in parte mediâ canaliculato, superficie modice convexâ, pone medium vagissime biimpressâ, magis dense sat subtiliter punctatâ; scutello transverso; elytris prothorace fere $1\frac{1}{5}$ latioribus, latitudinem maximam circa medium attingentibus, apice separatim obtuse rotundatis, sparse subtiliter, prothorace minus dense, punctatis, superficie vix rugulosâ, striâ suturali tenuissimâ fere ad scutellum attingente; alis nullis; mesosterno areâ mediâ angustâ, modice concavâ, lateribus haud acute elevatis; tarsis posterioribus in ♂ et in ♀ 5-segmentatis. Long. corp. c. 3.5–4 mm.

Dark brown, the hind part of the elytra sometimes obscurely reddish, antennae and legs dark ferruginous; subopaque, densely covered with pale yellowish decumbent hairs, not so short as in some species, and with a few erect hairs on the lateral and posterior parts of the elytra. *Antennae* moderately stout, second segment about equal in length to the basal, but narrower though considerably less than twice as long as broad, third slightly longer, nearly twice as long as broad, fourth about $\frac{2}{3}$ the length of the third and over $\frac{2}{3}$ as broad as its own length, fifth longer than fourth, but shorter than third, more than half as broad as its own length, sixth and seventh subequal, about the same length as fourth, sixth about $\frac{2}{3}$ as broad as its own length, seventh a trifle broader, eighth shorter than seventh and only slightly longer than its own breadth; ninth to eleventh forming the club, ninth and tenth not strongly transverse, terminal segment nearly as long as the two preceding taken together. *Head* closely and rather finely punctured, the interspaces often little more than the diameter of the punctures. *Prothorax* about $1\frac{1}{3}$ times as broad as long, broadest a little behind the middle, narrowing considerably towards the front margin and the base, a little broader at the hind than at the front angles, the sides forming a continuous curve except just before the hind angles, where they are slightly sinuate; viewed from above, the front angles are rounded off, the hind angles definite but slightly larger than a right angle; at the sides there is only a very fine and narrow margin, visible only under a high power, and no trace of callosity or oblique truncation in front; the base is bent slightly forwards on either side a little within the hind angle, and along the middle part there is a shining marginal channel, deeply impressed at either end; surface moderately convex, faintly impressed on either side of the median longitudinal line behind the middle and slightly elevated in the median longitudinal line towards the base, densely but rather finely punctured, many of the punctures are nearly contiguous, and a trace of very fine reticulation is visible in the interspaces under a high power. *Scutellum* strongly transverse. *Elytra* broader than the prothorax by nearly $\frac{1}{5}$ the breadth of the latter, reaching their greatest breadth in the middle part, with sutural margins depressed towards the apex, apical angles rounded, leaving a small angular space between the two; sutural stria an extremely fine depressed line, continued forwards nearly to the scutellum, with a rather wide interval between it and the margin, except in the apical part; puncturation fine, but less dense than on the prothorax, the interspaces being equal to twice the diameter of the punctures themselves, or more, while the surface shows faint traces of rugulosity. *Hind wings* absent. *Mesosternum* with median area long and narrow, nearly parallel-sided, moderately concave, elevated at the sides, but not so as to form a sharp ridge. *Metasternum* and *abdominal segments* finely and fairly densely punctured, with interspaces minutely reticulate. *Posterior tarsi* 5-segmented in both sexes.

Loc. Uganda: Ruwenzori, Bujuku, 12,000 feet, 16–19. viii. 1931, shaken from seeding inflorescences of *Lobelia Wollastonii*, four males, five females, and five specimens the sex of which has not been determined (*G. L. R. Hancock*);

Bujuku valley, 10,800 feet, 8. viii. 1933, from seed-stalk of *Lobelia Bequaertii*, two females (*W. J. Eggeling*).

Variation.—There is appreciable variation in size, and one male specimen is exceptionally small, being less than 3 mm. in length, though exhibiting no marked divergence from the normal in any other respect. Another male example (rather large) has the prothorax exceptionally broad in its widest part, and consequently more strongly narrowed to the base than in other specimens.

MNIONOMUS GIBBINSI, sp. n. (Fig. 8, *a.*)

M. hancocki affinis sed minor, colore clarior, flavescens; prothorace minus transverso, tantum circa $1\frac{1}{5}$ latiore quam longiore; mesosterno inter coxas intermediis fere plano. Long. corp. c. 3.0 mm.

Resembling *M. hancocki*, but smaller and lighter, the colour being yellowish. The prothorax is differently shaped, longer in proportion to its breadth; in *M. gibbinsi* the greatest breadth is about $1\frac{1}{5}$ times the length, in *M. hancocki* about $1\frac{1}{3}$. The mesosternum in *M. gibbinsi* is scarcely concave between the middle coxae, but almost flat, a little longer than broad, and narrows somewhat to the truncate hind end. The nature of the surface, degree of strength and closeness of puncturation, and the pubescence, are all much the same as in *M. hancocki*.

In *M. gibbinsi* the greatest breadth of the prothorax is at about the middle, the side margins curve inwards anteriorly and the front angles are rounded off; behind the middle the side margins are convergent and slightly sinuate to the hind angles, which are definite and slightly larger than right angles; the sinuation of the sides makes the base appear narrower than the front margin, though measurements with a camera lucida show the base to be very slightly wider; the sides are very finely and narrowly margined, the marginal channel along the middle part of the base is well marked and shining, and curves forwards to a deep punctiform impression at either end.

Loc. Uganda: Birunga Mts., Muhavura, c. 12,000 ft., 13. xii. 1932, on *Lobelia* sp., one male, two females, and two examples of undetermined sex (*E. G. Gibbins*). Mr. Gibbins informs me that the five beetles were all taken from a single plant, about one foot high, and that, though many plants were searched, specimens of the beetle were only found on this one. Judging from the locality and altitude, it may have been either *Lobelia karisimbensis* or *L. Wollastonii*.

MICRAMBE C. G. Thomson, 1863.

This genus has the prothorax furnished with callosities at the front angles, but, like *Mnionomus*, with no small tooth at the middle of the sides (thereby differing from *Cryptophagus*).

It was known that in some species the posterior tarsi are 5-segmented in both sexes, while in others they are 4-segmented in the male. Of the six

species described or discussed below, two exemplify the former, and four the latter, condition.

Normally the hind wings are fully developed and the metasternum is appreciably longer than the first abdominal segment—both of which characters distinguish the genus from *Mnionomus*. Five of the following species are normal in these respects. The remaining one (*M. subinfuscata*) is abnormal, having the wings reduced to vestiges and the metasternum very little longer than the first abdominal segment; as remarked under that species, it and certain other East African forms may prove to be intermediate between normal *Micrambe* and *Mnionomus*.

The form of the median area of the mesosternum has been used to some extent, but it is less distinctive in the species of this genus dealt with than in those of *Mnionomus*.

No key has been attempted, as many other species, not associated with *Lobelias* or *Senecios*, have been described from East and South Africa, and much undetermined material (of other species not connected with these plants) from Abyssinia and East Africa awaits study.

MICRAMBE SENECTIONIS, sp. n. (Fig. 11.)

Obscure fusca, elytris pone humeros necnon pone medium obscure rufescentibus (exempla nonnulla corpore fere toto rufescente, elytris solum suturâ et plagâ transversali mediâ fuscis), parum nitida, pilis curtis, pallidis, decumbentibus omnino vestita, pilis aliquibus longioribus, erectis, praesertim in partibus lateralibus et posterioribus elytrorum conspicuis, sparsis; antennis sat gracilibus; prothorace magis quam $1\frac{1}{4}$ latiore quam longiore, latitudinem maximam pone angulos anteriores attingente, basi angustiore, angulis anterioribus callosis et oblique truncatis, postice in dentem haud productis, angulis posterioribus argutis, fere rectis, marginibus lateralibus (pone angulos callosos) vix bisinuatis, in medio subangulosis, postice paulum ad basin convergentibus, his et margine basali tenuiter reflexis, basi utrinque foveolatâ, superficie (ut in capite) modice convexo, dense subtiliter punctatâ; scutello transverso; elytris prothorace conspicue latioribus, latitudinem maximam circa medium attingentibus, deinde lateribus arcuatis, convergentibus, apice separatim obtuse rotundatis, striâ suturali tenui, antice obsoletâ, superficie pone aream scutellarem vage depressâ, minus dense quam in prothorace punctatâ, vix rugulosâ; pedibus gracilibus, tarsis posterioribus in ♂ 4-, in ♀ 5-segmentatis. Long. corp. c. 3 mm.

Colour variable, usually very dark brown or blackish, with the posterior part of the elytra, and a patch in the humeral region of each, dark reddish, leaving a dark band across the middle and dark colour along the suture; in some specimens the reddish colour is lighter and more extended, even the head and thorax being more or less reddish; antennae reddish with the clubs darker; basal part of tibiae (and, in the lighter specimens, the femora also) reddish, apical part of the tibiae and tarsi dark. Surface not strongly shining, covered

with short, pale, decumbent hairs, with longer erect hairs scattered on the elytra, especially on the lateral and apical parts. *Antennae* rather slender, second segment less incrassate than first, nearly twice as long as broad, third slender, about $1\frac{1}{3}$ times as long as second and nearly three times as long as its own breadth, fourth shorter than second and about twice as long as its own breadth, fifth longer than fourth, about as long as second, sixth and seventh subequal in length, about as long as fourth but slightly broader, eighth short, very little longer than its own breadth; the proximal segment of the club is

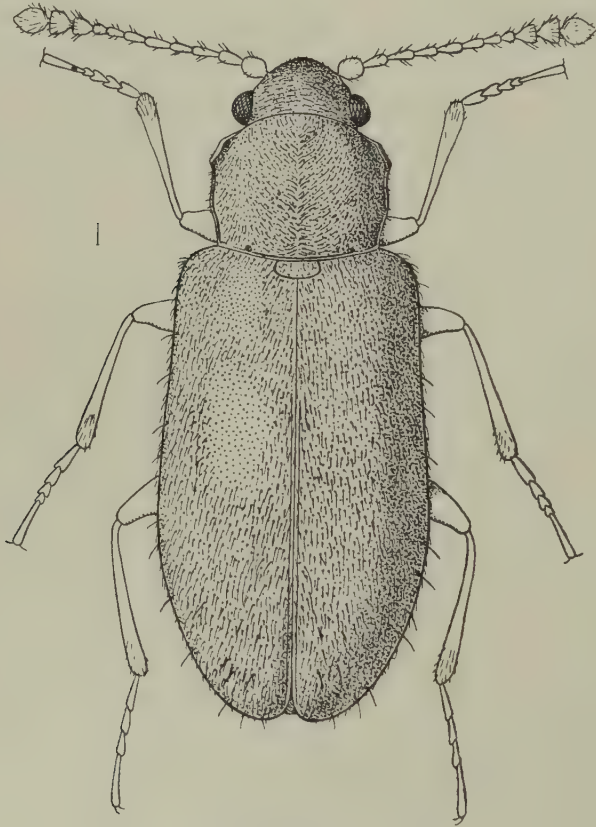


Fig. 11.—*Micrambe senecionis*, male.

nearly as broad as long, the tenth appears transverse in some positions, and the terminal segment is about half as long again as the tenth. *Head* triangular, its surface rather convex, closely and finely punctured, the interspaces approximately equal to the diameter of the punctures. *Prothorax* more than $1\frac{1}{4}$ as broad as long, broadest at the hind end of the callosities, then narrowing considerably to the base; front angles callose and obliquely truncate, hind angles definite but slightly larger than right angles; the middle part of the front margin is not

reflexed, but the sides, both before and behind the callosities, are finely reflexed; the callosities are not produced into a tooth behind, and, seen in side view, narrowly ovoid; behind the callosities the sides are faintly bisinuate, almost angular at about the middle, scarcely convergent in front of this point, but, behind it, converging slightly to the base; the base has a reflexed margin, somewhat explanate on either side between the hind angle and a small punctiform impression; surface moderately convex, puncturation much the same as that of the head. *Scutellum* transverse, subtruncate behind. *Elytra* much broader than prothorax, broadest at about the middle of their length, then curving inwards to their blunt, separately rounded extremities; surface vaguely depressed behind the humeral and scutellar region, and along the suture; a fine sutural stria is present in the posterior part, but becomes obsolete in front; punctures wider apart than on the prothorax, and surface showing, under a high power, faint traces of wrinkling. *Hind wings* fully developed in both sexes, in two examples measured the wing is almost exactly twice as long as the elytron and more than twice as wide. *Underside* closely and finely punctured. *Legs* and *tarsi* rather slender, the hind tarsi 4-segmented in the male, 5-segmented in the female.

Loc. Uganda: Ruwenzori Mts., Bujuku, 12,000 feet, viii. 1931, on inflorescences of *Senecio*, eighteen males, fourteen females (G. L. R. Hancock). Mr. Hancock has told me that the beetles were on the flower-heads, and were collected by pulling the latter open, and that the *Senecio*-plants were either *S. adnivalis* or *S. erioneuron*, or possibly both these species.

MICRAMBE KIGOENSIS, sp. n.

M. senecioni affinis, sed minor ac magis nitens; prothorace brevior, valde transverso, lateribus (de latere visis) paulum pone angulos anteriores callosos sat abrupte sursum flexis, subtiliter crenulatis; colore variabilis, obscure fusca vel nigrescens, elytrorum basi plerumque, apicibus interdum, plus minusve ferrugineis, parte intermediâ elytrorum ad suturam, et prothorace in exemplis nonnullis, etiam rufescentibus. Long. corp. c. 2.6 mm.

Smaller and more shining than *M. senecionis*. Variable in colour, dark brown or blackish, usually more or less ferruginous at the base of the elytra; sometimes the apical region of the elytra is also ferruginous, and the reddish colour may extend along each elytron close to the suture, uniting the basal and apical reddish areas; in some examples the prothorax is also more or less reddish, and a few are almost wholly ferruginous, with only the lateral parts of the elytra darker. *Prothorax* strongly transverse, broader in proportion to its length than in *M. senecionis*, and differently shaped at the sides; the truncate surface of the callosities has its upper edge markedly reflexed, while the lateral margins, seen from the side, are rather abruptly bent upwards at a point a little behind the callosity, and, seen from above, are slightly but distinctly crenulate; the surface is, in some specimens, a little less closely punctured in the middle than in *M. senecionis*. *Posterior tarsi* 4-segmented in male, 5-segmented in female,

The median area of the *mesosternum* does not provide distinguishing characters between this and the preceding species. It has nearly the same form in both, rather longer than broad, with sides slightly converging to the posterior margin, which is nearly truncate; surface rather coarsely punctured anteriorly, concave and impunctate in the posterior part.

Loc. Uganda: Ruwenzori Mts., Kigo, 11,000 ft., viii. 1931, one male, shaken from inflorescences of *Lobelia Bequaertii*, together with specimens of the two species of Corylophidae described herein (*G. L. R. Hancock*). Belgian Congo: West Ruwenzori, at head of River Nyamuamba, 4,200 metres (nearly 13,800 ft.), vii. 1932, twenty-seven examples (*L. Burgeon*); no record was kept as to whether these were collected from *Lobelia Wollastonii* Baker, *Senecio erioneuron*, or *Helichrysum* sp.

This species was described from the single example (the type) collected by Mr. Hancock, which, at the first sorting, was placed in the series of *M. senecionis*, but was afterwards separated as not corresponding closely enough with the rest, while subsequently I noticed that it was found in quite a different locality and on a different plant. The numerous specimens from West Ruwenzori came to hand much later, but their characters agree so well with those of the Kigo specimen that no change in the description was needed, except in the matter of the variable coloration. The example from Kigo is known to have been taken from a *Lobelia*, and probably the species as a whole is associated with these plants.

MICRAMBE EGGELINGI, sp. n. (Fig. 12, a.)

Picea, fere unicolor, elytris piceo-nigris, apicibus parum rufescentibus, capite et prothorace et scutello plus minusve piceo-rufis; nitida, inter puncta haud reticulata, pilis pallide flavescentibus decumbentibus (in elytris aliquibus longioribus, fere erectis) vestita; capite prothoraceque sat fortiter ac dense, elytris paulum subtilius, punctatis; prothorace valde transverso, fere $1\frac{1}{2}$ latiore quam longiore, angulis anterioribus truncato-callosis et paulum sursum flexis, lateribus bisinuatis, ad angulos posteriores sat fortiter convergentibus, his multo magis quam rectis, disco haud aequo, in medio ante basin paulum elevato, utrinque vage aliquoties impresso; scutello brevissimo, margine posteriore subtruncato; alis amplis; metasterno in medio parce punctato, fere glabro; tarsis posterioribus in ♂ et in ♀ 5-segmentatis. Long. corp. 2.8–fere 3.4 mm.

Almost unicolorous, elytra pitchy-black with dull reddish apices, head, prothorax, and scutellum more or less pitchy-reddish, antennae and legs dark ferruginous; shining, not reticulate between the punctures, covered with pale yellowish decumbent hairs, with scattered, longer, nearly erect, hairs on the elytra; head and prothorax moderately strongly punctured, the punctures often little more than their own diameter apart; on the elytra the punctures are slightly finer. *Prothorax* strongly transverse, its greatest breadth only a little under $1\frac{1}{2}$ times its length; the truncate surfaces of the callosities at

the anterior angles are somewhat upturned, and consequently more visible from above than in some species, while in side view they are almost elliptical, but pointed at each end; behind the callosities the sides are bisinuate (the anterior sinuation shorter and less marked than the posterior) and converge considerably to the hind angles, which are much wider than right angles; sides finely margined, base somewhat explanate, with traces of foveoles on either side; disk not quite even, there is a slight median elevation just in front of the base, and vague impressions and elevations on either side. *Scutellum* very short and transverse, subtruncate behind. *Elytra* vaguely impressed near the suture a little behind the base, and each with a fine sutural stria, becoming obsolete towards the base. *Hind wings* ample, each more than twice the length of the elytron and considerably wider. *Mesosternum* with median area slightly concave, the process between the coxae about as wide at the hind end as in front, and with hind margin subtruncate. *Metasternum* sparsely punctured

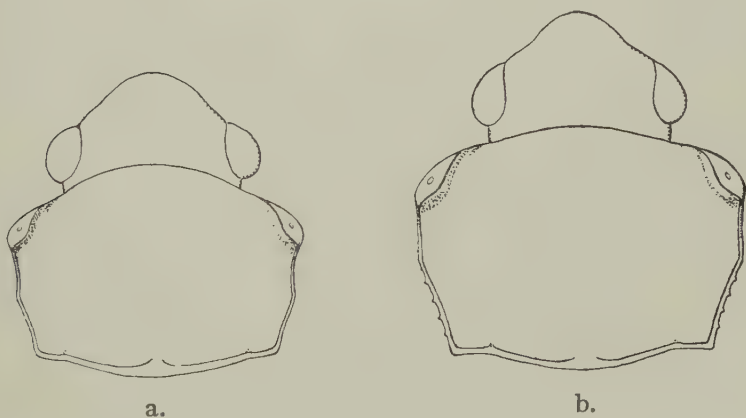


FIG. 12.—Outline of prothorax of *a*, *Micrambe eggelingi*; *b*, *M. varicolor*. Both $\times 45$.

and almost glabrous in the middle, otherwise fairly closely punctured; *abdominal segments* very finely but rather closely punctured. *Posterior tarsi* 5-segmented in both sexes; there is no external character differentiating the sexes, and examples could only be determined as to sex by dissection.

Loc. Uganda: Ruwenzori, Bujuku Valley, 10,800 ft., 8.viii.1933, two males, one female, and two examples of undetermined sex, 'from seed-stalk of *Lobelia Bequaertii*' (W. J. Eggeling).

M. senecionis and *M. kigoensis*, both occurring in Ruwenzori, have a dark coloration and are about the same size as *M. eggelingi*; but both have the posterior tarsi only 4-segmented in the male. Also, *M. senecionis* has the prothorax differently shaped, considerably longer in proportion to its breadth, and differs also in being less shining and in details of colouring and puncturation. *M. kigoensis* is smaller and differs in details of colouring, and, although the

prothorax is nearly as transverse as that of *M. eggelingi*, it is differently shaped, the callosities being less upturned and the sides not distinctly bisinuate and less narrowed to the hind angles. *M. eggelingi* has also some superficial resemblance to *M. varicolor* Grouvelle, some remarks on which are made below.

MICRAMBE VARICOLOR Grouvelle. (Fig. 12, b.)

Micrambe varicolor Grouvelle, in Sjöstedt, Kilimandjaro-Meru Expedition, i, 7, p. 331, 1909.

I have examined, from the series on which Grouvelle's description was based, a single example (male) which, M. Lesne has informed me, agrees closely with the type, except that the latter is an immature specimen and lighter in colour. Examination of the specimen before me has shown that the wings are fully developed. The posterior tarsi are 4-segmented (in the original description, by a slip, 'femelles hétéromères' was given); moreover, the fifth (last exposed) sternite has a median apical impression, almost certainly a secondary sexual character, and one which I have not observed in any other species of African Cryptophagidae. The metasternum of this specimen has a narrow median longitudinal glabrous area, almost impunctate, extending from before the middle to the hind margin; and the median area of the mesosternum is concave, with sides slightly convergent to the hind end, and posterior margin slightly sinuate to receive the front of the metasternum.

Apart from the heteromerous condition of the tarsi, this male example is about the same size as, and has some superficial resemblance to, the specimens of *M. eggelingi*. It is almost uniformly dark, but its prothorax, though as strongly transverse as that of *M. eggelingi*, is a different shape, the sides being almost straight and parallel for about half the distance between the callosities and the base, then converging strongly (but scarcely sinuate at all) to the base; the prothorax also is more closely punctured, and it and the head are less convex; the whole of the surface is duller, owing to being minutely reticulate between the punctures.

Loc. Mt. Kilimanjaro: it is recorded that many specimens were collected at Kiboscho, 3,000–4,000 metres (about 9,800–13,100 ft.), from old inflorescences of *Lobelia Deckenii*.

MICRAMBE SUBINFUSCATA Grouvelle.

Micrambe subinfuscata Grouvelle, in Sjöstedt, Kilimandjaro-Meru Expedition, i, 7, p. 332, 1909.

By the courtesy of the Paris Museum, I have had before me six examples from the series on which Grouvelle based the original description of this species. It proves, on examination of four specimens, that the wings are vestigial; they are narrow, and between $\frac{1}{4}$ and $\frac{1}{3}$ the length of the elytron. This raises the question whether the species should be transferred to *Mnionomus*, but I have decided to leave it in *Micrambe* for the present, on account of its general configuration and because the metasternum is a little longer than the

first abdominal segment (this is best seen by comparing the distance from behind the middle coxa to the hind margin of the metasternum with that from behind the posterior coxa to the hind margin of the first abdominal segment), though not nearly as much so as in some fully winged species of *Micrambe*. Moreover, the relationships of certain unnamed east African specimens with wings almost as long as the elytron, i.e. intermediate between the vestigial and the fully winged condition, have not yet been made out.

M. subinfuscata is a relatively small insect, the examples before me measuring about 2 mm. long (1.5 mm. was given in the original description). The prothorax is strongly transverse, its greatest breadth nearly $1\frac{1}{2}$ times the length; the truncate surface of the callosities, seen from the side, is not elongate, but nearly circular. The colour is castaneous, with a blackish patch, not sharply defined, on the middle part of each elytron, extending almost or quite to the suture, but not to the deflexed lateral portion; disk of prothorax, and head, also blackish in some specimens, also the sterna and anterior abdominal segments; surface shining, puncturation of prothorax and elytra not very close, hairs less dense than in some species. Posterior tarsi 4-segmented in male, 5-segmented in female (the sex of a heteromerous individual was determined by dissection; in the original description, evidently by a slip, Grouvelle wrote 'femelle hétéromère').

Loc. Mt. Kilimanjaro: it is recorded that many examples were taken at Kiboscho, 3,000–4,000 metres (about 9,800–13,100 ft.), often in old inflorescences of *Lobelia Deckenii*.

MICRAMBE BUJUKUENSIS, sp. n. (Fig. 13.)

Fulva, elytris maculâ latâ nigrâ de basi pone medium longitudinis, et transversum (ante medium) usque ad margines laterales, extensâ; nitida, inter puncta haud reticulata, pilis pallidis, curtis, decumbentibus (in elytris aliquibus longioribus suberectis) vestita; capite prothoraceque subtiliter sat dense punctatis, elytris subtilius punctatis, vix rugosis; prothorace valde transverso, magis quam $1\frac{1}{4}$ latiore quam longiore, angulis anterioribus truncato-callosis, lateribus in parte mediâ vix convergentibus, deinde magis convergentibus et leviter sinuatis, angulis posterioribus fere rectis; scutello valde transverso, margine posteriore late arcuato; alis amplis; tarsis posterioribus in ♂ et in ♀ 5-segmentatis. Long. corp. 2.5–2.9 mm.

Fulvous, with a broad black patch occupying the two elytra from the base to a little behind the middle, and extending a little further back along the suture; the black colour extends as a transverse band in front of the middle, and expands again forwards and backwards on the deflexed lateral part, but the humeral region (with the scutellum) and a large part behind the middle are fulvous; antennae and legs fulvous, distal part of tibiae and tarsi darker; sterna and ventral abdominal segments black; surface shining, not reticulate between the punctures, covered with short, pale golden, decumbent hairs,

and with scattered, longer, nearly erect hairs on the elytra; head and prothorax rather finely punctured, the punctures often little more than their own diameter apart; on the elytra the punctures are finer and the surface slightly wrinkled. *Antennae* with segment 3 about twice as long as 4, and about one-fifth longer than 5. *Prothorax* strongly transverse, over $1\frac{1}{4}$ times as broad as long, front angles truncate-callose, sides only slightly convergent behind the callosities, then they bend inwards, converging more strongly and slightly sinuate, to the hind angles, which are nearly right angles; sides finely margined behind the callosities, base explanate, more widely in the middle,

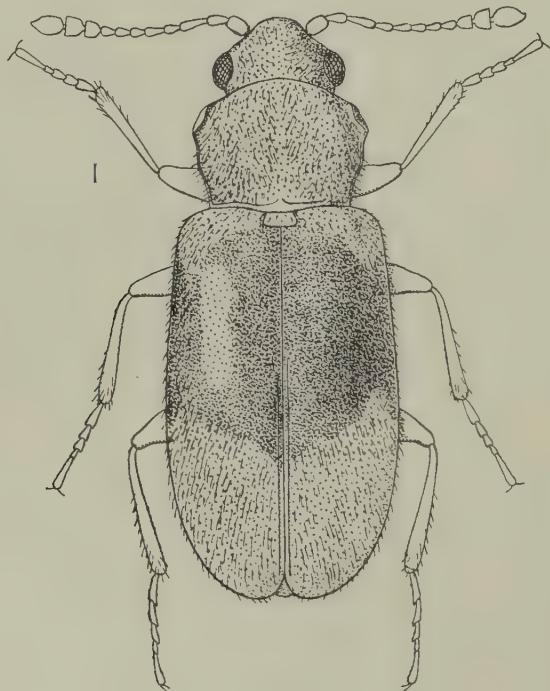


FIG. 13.—*Micrambe bujukuensis*.

and with an indication of a very fine and short median longitudinal keel. *Scutellum* strongly transverse, posterior margin widely curved. *Elytra* with a fine sutural stria extending from the apex to before the middle. *Hind wings* ample, each more than twice the length and about double the breadth of the elytron. *Mesosternum* with median area strongly concave, the raised lateral margins slightly convergent to the posterior end, posterior margin truncate. *Metasternum* and *ventral abdominal segments* rather finely and closely punctured. *Posterior tarsi* 5-segmented in both sexes (examples of the two sexes were determinable only by dissection).

Loc. Uganda : Ruwenzori, Bujuku Valley, 10,800 ft., 8. viii. 1933, one male, four females, and two examples of undetermined sex (*W. J. Eggeling*) ; ' from seed-stalk of *Lobelia Bequaertii*'.

I have seen no other specimens indentical with those described above. Some unnamed examples in the collections of the Paris Museum, collected in Kilimanjaro by Messieurs Alluaud and Jeannel, resemble the Bujuku specimens fairly closely, but plainly belong to a distinct species. A consideration of the Kilimanjaro specimens must be deferred until a critical examination of certain other East African material can be made.

ATOMARIA Stephens, 1830.

ATOMARIA (ANCHICERA) CHILLALOENSIS, sp. n. (Fig. 14.)

Ovata, nitida, pilis brevibus, pallidis, decumbentibus vestita, castaneo-brunnea, elytris ad basin atque ad suturam parum ferrugineis, tibiis antennisque ferrugineis, harum clavis obscurioribus ; prothorace valde transverso, maximam latitudinem paulum ante medium attingente, antrorsum valde, ad basin paulum, angustato, lateribus pone medium vix sinuatis, his et basi tenuiter marginatis, marginibus lateralibus desuper solum in parte posteriore visibilibus, angulis posterioribus magis quam rectis, parum obtusis, disco sat fortiter convexo, sat fortiter (praecipue ad basin) punctato ; scutello valde transverso ; elytris prothorace circa $\frac{1}{3}$ latioribus, latitudinem maximam ante medium attingentibus, lateribus late arcuatis, apicem-versus subrectis, apicibus vix separatis, subtruncatis, marginibus lateralibus desuper solum in parte quartâ posteriore visibilibus, striâ suturali tenui, ante medium obsoletâ, superficie convexâ, ad basin intra humeros et versus suturam utrinque vage depressâ, subtiliter punctulatâ, punctis quam in prothorace subtilioribus et minus densis, interstitiis laevis. Long. corp. c. 1.5 mm.

Ovoid, shining, rather sparsely covered with short, pale, decumbent hairs ; dark chestnut-brown, the elytra ferruginous at the base (especially in the humeral region) and along the suture, antennae ferruginous with clubs darker, tibiae ferruginous and tarsi even lighter. *Antennae* with second and third segments subequal, fourth little more than half as long as third, fifth longer than fourth, but appreciably shorter than third, sixth almost equal in length to fourth, seventh a trifle longer and stouter than sixth, eighth short and subglobular ; ninth and tenth nearly as long as broad, eleventh about one-and-a-half times as long as tenth. *Head* not very closely punctured, the eyes (viewed from above) hardly protrude from the general outline. *Prothorax* strongly transverse, viewed from directly above it appears more than one-third broader than long ; front edge with no thickened or reflexed margin, sides and base finely margined, the side margins being only visible from above in the posterior half, in front of which the prothorax narrows strongly to the front angles and the margins slope downwards and are hidden by the overhanging convexity of the surface ; the greatest breadth is just before the middle, behind which

the sides are faintly sinuate and converge slightly to the hind angles, which are larger than right angles and slightly blunted; base slightly produced backwards in the middle, so that the slightly concave part of the surface, immediately in front of the margin, is a little wider there; disk rather strongly convex, rather strongly punctured, especially at the base, the punctures separated by distances in some cases equal to, in some cases more than, their own diameter, the interspaces very smooth and shining. *Scutellum* short, strongly transverse. *Elytra* with sides forming a wide curve, broadening considerably from the base, reaching their greatest breadth (where they are approximately one-third broader than the prothorax), a little before the middle; lateral margins hidden from above by the overhanging convexity of the sides, except in the apical part, where they are visible, extremely finely reflexed, and cause a slight flattening in the outline; apices slightly separated and

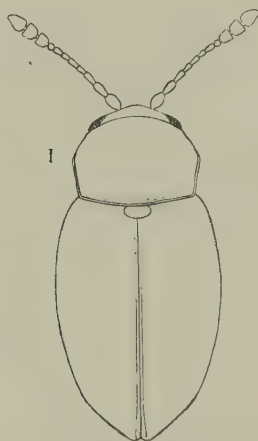


FIG. 14.—*Atomaria chillaloensis*.

subtruncate; sutural stria an appreciable distance from the margin near the apex, continued forwards in front of the middle as a very fine line close to the margin, becoming obsolete towards the base; surface rather strongly convex, very slightly depressed at the base just inside the shoulder and on either side of the suture, with fine punctures, finer and further apart than those on the prothorax, and interspaces smooth and shining. *Tarsi* slender, the posterior pair 5-segmented.

Loc. Abyssinia: summit of Mt. Chillalo, c. 12,000 ft., 21. x. 1926, in wet decaying substance under the loose bark of a dead stem of *Lobelia Rhyncho-petalum*, one example, taken together with specimens of *Mnionomus rhyncho-petali* (Scott).

This insect was probably only accidentally associated with the *Lobelia*, as a second specimen, found in a different locality, and not associated with

Lobelias, almost certainly belongs to the same species. The second example, however, has the clubs of the antennae not darkened; it is not so well preserved as the type, and consequently comparison of minute details is difficult; I have, therefore, labelled the second specimen '*Atomaria chillaloensis*, var. ?' I was able to examine its *hind wings*, which are fully developed and longer than the elytra. The locality is: Jem-Jem Forest, nearly 9,000 ft., 24. ix. 1926 (*Scott*).

I have seen examples of about thirty of the described species of the sub-genus *Anchicera* (all of which are Palaearctic), but none resembles *A. chillaloensis* very closely. The European *A. peltata* Kraatz has a certain resemblance, but is a decidedly larger insect, longer and narrower in proportion; its colour is, on the whole, darker, especially the prothorax, the elytra (excepting their hind part), and the distal portions of the tibiae; the prothorax is more narrowed, behind the middle, to the base, and appears slightly longer in proportion to its breadth; the puncturation of the elytra is coarser and their surface shows traces of rugulosity. On the other hand, two specimens of an unnamed *Atomaria*, lent by the Paris Museum and bearing the data 'Afrique orientale (*Eichelbaum*): Collection Grouvelle', closely resemble *A. chillaloensis*, but are not identical. In the East African *Atomaria*, the bend in the sides of the prothorax is even more angular and is situated at about the middle (not before the middle) of the length; the clubs of the antennae are not darkened; the puncturation of prothorax and elytra is much more nearly equal in strength; the gutter-like depression in front of the basal margin of the prothorax is a little broader in the middle, but tapers out and vanishes on either side at the hind angles, while in *A. chillaloensis* it is more nearly the same breadth throughout, and is continued vaguely round the hind angles. Lastly, the East African insect appears very slightly smaller and narrower, and has the curve of the sides of the elytra more nearly continuous to the apex.

Scolytidae.

THAMNURGUS Eichhoff, 1864.

The Palaearctic species of this genus live monogamously in the stalks of various herbaceous plants. *T. varipes* Eichh. attacks *Euphorbia amygdaloides*; *T. kaltenbachi* affects *Teucrium*, *Origanum*, *Lamium*, and *Betonica*; *T. delphinii* Rosenh. makes little gall-like swellings on the small stems ('fusticini') of *Delphinium longipes*; and *T. petzi* Reitter mines in, and makes gall-like swellings on, the shoots of *Aconitum*. The examples of the Abyssinian species described below were found in the inflorescence of a tree-Lobelia on Mount Zukwala, and the Ugandan species with which it is closely related is associated with the inflorescences of other species of tree-Lobelias in Ruwenzori.

I have failed to detect in either the Abyssinian or the Ruwenzori species the fine median longitudinal keel on the head which is present in some, at any rate, of the Palaearctic representatives of the genus, and is mentioned as

a generic character of *Thamnurgus* by Reitter, 'Fauna Germanica, Käfer,' v, p. 296, 1916.

THAMNURGUS ZUKWALAE, sp. n.

Form cylindrical, rather narrow. Colour reddish-brown, only the head, the underside, and the extreme lateral deflexed parts of the elytra are pitchy-black; prothorax in some specimens nearly as clear reddish as the elytra, but usually dark pitchy-reddish, with the front and the middle of the base a little lighter reddish; legs and antennae reddish-brown, the latter with the clubs darker. Surface moderately shining, with erect, pale yellowish, hairs. *Head* closely and finely punctured, surface wrinkled, a rather thick fringe of hairs along the front margin above the bases of the mandibles. *Prothorax* longer than broad, narrowed and rounded in front, narrower and with sides more nearly parallel in the female, broader and with sides more arcuate about the middle in the male, hind corners obtuse and rounded off; surface closely punctured, raised round the punctures in such a way as to give it an almost granulate appearance, the interspaces are also extremely finely reticulate (this being visible only under a high power) while a narrow mid-longitudinal line is nearly impunctate. *Scutellum* very small, subtriangular, smooth. *Elytra* a little wider than the prothorax; in the female nearly parallel-sided, in the male broader and widening gradually backwards, to a point beyond the half of their length; in both sexes narrowing to form a widely arcuate outline at the hind end; dorsally the surface is fairly regularly seriatly punctate (punctures two or more times their own diameter apart), and the intervals nearly smooth, with only slight wrinkling, more noticeable towards the base, but on the sloping sides the wrinkling is stronger and the puncturation less regular; in the female the puncturation and surface continue much the same over the posterior declivity; in the male the sutural margins are slightly elevated on the posterior declivity, and the surface is slightly concave on either side of the suture, while a fine transverse wrinkling is visible near the suture. *Underside* fairly strongly and closely punctate, the punctures much finer and sparser on the middle of the metasternum. *Tibiae* with outer edge sharply toothed, except towards the base.

Length c. 2.6 mm.

Loc. Abyssinia: Mt. Zukwala, c. 9,600 ft., 25. x. 1926, shaken from fetid dying inflorescence of *Lobelia giberroa*, in a small patch of forest on the highest point of the crater-wall, eleven examples (*Scott*).

This species closely resembles *Thamnurgus lobeliae* Eggers*, discovered by Mr. G. L. R. Hancock in the inflorescences of tree-Lobelias on Ruwenzori at 11,000 and 12,000 feet in 1931 (Mr. Hancock tells me that the species of *Lobelia* recorded after the description of the beetle as '*Lobelia Deckenii*' has since proved to be *Lobelia Bequaertii*, while the bionomic note 'on *Lobelia* seeds' refers to *L. Wollastonii*). But, having before me the type and

* '*Stylops*,' ii, p. 23, Jan. 1933.

a long series of examples of *Thamnurgus lobeliae*, I find that it is a darker and more coarsely sculptured insect than *T. zukwala*. The elytra are in some specimens almost uniformly pitchy-black, or, if reddish, they are a dark pitchy-reddish, and blackish along the suture as well as at the sides; the prothorax is uniformly pitchy-black, without the reddish areas in front and at the base. Under a high power the interspaces between the punctures on the prothorax appear much more distinctly and closely reticulate in *T. lobeliae*, and it also has the elytra much more wrinkled, even dorsally. The pubescence appears a trifle longer in some specimens of *T. lobeliae*. The differences are not easy to express, but in colour and sculpture they are so constant throughout the series of specimens that I have no hesitation in regarding the two forms as distinct species.

SUPPLEMENT.

The following remarks and description, concerning two of the species of Staphylinidae included in the Table (p. 238), were received from Dr. Bernhauer as this paper was being completed :—

ATHETA (PLATARAEA) SUPREMA Bernh., Rev. Zool. Bot. Afr. xxiv, p. 244, 1934.

This is the species mentioned as '*Atheta ugandae* Bernh.' by Fishlock and Hancock, Journ. East Africa and Uganda Nat. Hist. Soc., no. 44, 1932, p. 225 (publ. Jan. 1933).

Loc. Ruwenzori: Bujuku, 12,500 ft., on flowers of *Senecio adnivalis* and/or *S. erioneuron*, 1931 (Hancock); Bujuku, 13,800 ft. (4,200 m.), vii. 1932 (Burgeon).

TROPOSIPALIA HANCOCKI, sp. n.

'*Trogosipalia* [sic] *hancocki* Bernh.', mentioned, Hancock & Soundy, Journ. East Africa & Uganda Nat. Hist. Soc., no. 36, 1929, p. 173 (publ. Jan. 1931).

This species forms, together with *T. spectabilis* Bernh., a peculiar group within the genus, distinguished from the other species by the short and broad head, larger eyes, strong and close sculpture of the fore part of the body, as well as by the broad build of the body. I therefore propose a new subgenus, *Brachysipalia*, for these two species.

T. hancocki is easily distinguished from *T. spectabilis* by its smaller body, scarcely amounting to $\frac{1}{3}$ that of the latter species, by its strongly and closely punctured head, much longer, more strongly punctured and much more dully shagreened prothorax, much more diffusely punctured, and laterally strongly furrowed, elytra, and much more diffusely punctured abdomen.

Pitchy-black, with somewhat lighter prothorax and elytra, the antennae, palpi, and legs rust-red; sparsely clothed with fine yellow hairs. *Head* more than half as broad as prothorax, transverse, broadest near the posterior end, with sides behind the eyes rounded like cheeks, broadly impressed along the

middle, coarsely and closely punctured, with the surface between the punctures dull shagreened. Eyes proportionately large, coarsely faceted, and prominent, the temples behind the eyes only about double as long as the longitudinal diameter of the eyes viewed from above. Antennae fairly long, slender, but clearly broadened towards the apex, third segment as long as second, the following segments longer than broad, the penultimate segments a little broader than long, terminal segment large, longer than the two preceding taken together. *Prothorax* somewhat narrower than elytra, as long as broad, almost circular, rather finely and very closely punctured, with the surface between the punctures very finely and extremely closely dull shagreened, with a dimple-like impression in front of the scutellum; the downward turned lateral parts broadly visible in side view. *Elytra* very short, less than half as long as the prothorax, broadly and deeply furrowed near the side margins, rather finely and diffusely, yet somewhat roughly, punctured, with the surface between the punctures dull shagreened. *Abdomen* broader than the fore part of the body, broadened in the middle, transversely furrowed at the base of the first three exposed segments, finely and diffusely, in the posterior part even more sparsely, punctured. *Length* 5 mm.

Loc. Uganda: Mt. Elgon, above 12,000 ft., under decaying leaves of *Lobelia elgonensis*, 20. viii. 1929 (G. L. R. Hancock).

Type and paratype in the British Museum, and paratypes in Coll. Bernhauer.

[*Wings*.—I examined a paratype and found hind wings quite absent; nothing was said about these organs in the original description (1930) of the genus. Certain related forms (*Sipalia* spp.) are also wingless.—H. S.]

NOTE.—The drawings were all made with the help of a drawing apparatus; the anatomical details in figures 1, 3, and 5 (from preparations in balsam) by the author, the remainder (from carded specimens) by Miss O. F. Tassart.

Some eco-climatic data for closed Evergreen Forest in Tropical Africa. By R. E. MOREAU, C.M.Z.S., M.B.O.U., East African Agricultural Research Station, Amani. (Communicated by WILLIAM NOWELL, C.B.E., D.I.C., F.L.S.)

(With 3 Text-figures)

[Read 10 January 1935.]

THE data dealt with in this paper were obtained in connexion with studies on bird ecology in the Usambara Mountains of Tanganyika Territory (Moreau 1934, and in press). The fact that an interesting specialized fauna is perennially confined to the shaded depths of the forests made it desirable to ascertain to what extent the climate in the interior of the forest and close to the ground differs from the climate as recorded under the conditions of a standard meteorological station. The enquiry is of the more general interest because the forest fauna encountered in Usambara is in the main common to several of the highly discontinuous areas of Evergreen Forest scattered over the African tropics. The data obtained are limited in scope by the special object in view, but they appear to be the first of their nature to be put on record for Evergreen Forest in Africa.

Continuous records of temperature and humidity were maintained for over twelve months in 1931 and 1932, during which period several sets of light-intensity readings were also secured. The measurements were made in the Intermediate Forest at Amani (3,000 ft.) and in the neighbouring Lowland Forest (1,150 ft.). Botanical descriptions of these forests have been given (op. cit.), and some idea of their general appearance can be gathered from the plates illustrating them. The Intermediate Forest is a magnificent growth, unsurpassed in luxuriance anywhere in East Africa. Tall white-trunked trees rise in a close stand often for a hundred feet without a branch. Their heads are, however, comparatively small: they do not interlock, and flecks of sunlight frequently reach the ground. There is a kind of under-storey of forest, somewhat sparse as a rule, from 20 to 40 ft. high, and often a thick dark green shrubby undergrowth 3-6 ft. high. The Lowland Forest is rather less tall and dense, with a canopy more open and uneven.

Sites and methods: temperature and humidity.

The temperature and humidity were recorded with thermo-hygrographs in screens 4 ft. above the ground. This agrees with the height at which the standard climate is obtained in standard meteorological stations: and,

equally important, it provides data of the climate inhabited more or less continuously by a large proportion of the forest bird population. Four feet above the ground is within the zone of most abundant undergrowth, and of nesting activity. Moreover, data collected in the North Temperate Zone (Geiger 1927) lead one to expect that the climate at a height of 4 ft. in forest extends for some distance upwards with little variation.

The thermo-hygrographs used were checked occasionally and also interchanged: but an accuracy within 1° C. cannot be claimed for instruments of this type. Also, the observations were made with such instruments as happened at the time to be available at the Research Station. One result is that it was not possible to obtain open-air data directly comparable with the Lowland Forest site, so that of the Lowland Forest records obtained only those for daily range are available for direct and detailed comparison here with those for Intermediate Forest.

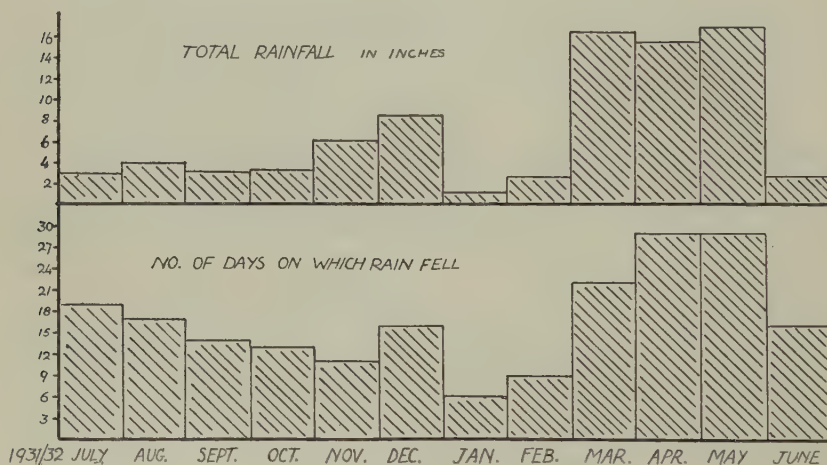


FIG. 1.

The choice of sites naturally presented difficulties. It is well known that even in country that appears to be uniform in all significant respects appreciable local effects show themselves. These must be comparatively large in a place like Amani which is mountainous, with a multitude of different eco-climates conditioned by slope, aspect, and degree of exposure, as well as by vegetation. Even with unlimited instruments with which to obtain a multiplicity of data for averaging, no finality could be reached under the heterogeneous natural conditions. There was also the difficulty that if the open-air site chosen was close enough to the inside forest site to be fully comparable with it in aspect and other particulars, it was bound to come within range of the influence of a large mass of forest on the adjacent standard climate.

In these difficult circumstances a makeshift was adopted that does at least give an idea of the magnitude of the place effect to be expected locally between sites chosen to represent so far as possible general and not extreme conditions. A thermo-hygrograph was installed in a screen seventy yards inside the edge of an area of Intermediate Forest that in other directions extended unbroken for at least a mile. The ground sloped south-eastwards, but in other respects the site was as typical as could be found, in fully developed primary forest, with an average density of under-storey trees and undergrowth of spindly shrubs. One hundred yards away a second recording instrument was installed on the same south-east slope, but in a plot containing poorly grown coffee bushes. It is thought that these may have been small and sparse enough not to influence the instrument among them significantly. But, on the other hand, as the site was barely 30 yards from the forest edge it may have been affected by the proximity. As a check I have utilized the readings at the Amani meteorological station which has been maintained for about thirty years. It is situated about three-quarters of a mile from the other two sites on the crest of an exposed ridge and surrounded by short grass. The temperature records there are taken with maximum and minimum thermometers, which should on the whole be more sensitive than the thermo-graphs. The Main Station is 120 ft. lower, a difference too small in itself to have an appreciable effect.

In order that the variation in the mutual climatic relations of the three sites through the seasons may be connected with sky conditions, fig. 1 has been prepared to show from the Main Station records the monthly totals of rainfall in inches, and, as a very rough indication of the relative cloudiness, the number of days on which rain fell in each month. The period under review is normal as regards the amount and the seasonal distribution of the rainfall. The amount of water reaching the floor of the forest will differ from the standard record. For one thing a large proportion of the rainfall, especially when it is not heavy, is retained by the canopy. On the other hand, low mists are common at certain seasons and times of the day. The so-called 'occult precipitation' from them when they get entangled in the forest must be considerable.

Temperature.

Fig. 2 compares the mean monthly maxima and minima at the Main Station and outside the edge of the Intermediate Forest. The differences between the two barely reach 1° C. in any month. The Main Station maxima are, as a rule, slightly the lower. The small differences between two such differently conditioned open-air sites leave no doubt as to the significance of the difference between open air and forest next to be described.

The mean monthly maxima inside the Intermediate Forest and just outside it are also compared in fig. 2. The forest maxima are consistently lower by 3° to 4° C. except in the very wet and cloudy month of May, when the

difference is hardly more than 2°C . The differences between the forest and the Main Station are on the whole slightly less, but they are more regular, within 0.5°C . of 3°C ., May not excepted. The 3° reduction in maxima thus established for the Amani Forest agrees closely with that found in the only other African study available, by Phillips (1931) in the extra-tropical Knysna Forest.

Between the mean monthly minima in the Intermediate Forest and outside the forest edge, the differences are less than 1°C ., except in July and August. In the latter month the difference rises to 2°C . It is doubtful whether this is not accidental. Records were maintained after June 1932, and the difference in August 1932 was barely 1°C . (Between the Main Station minima

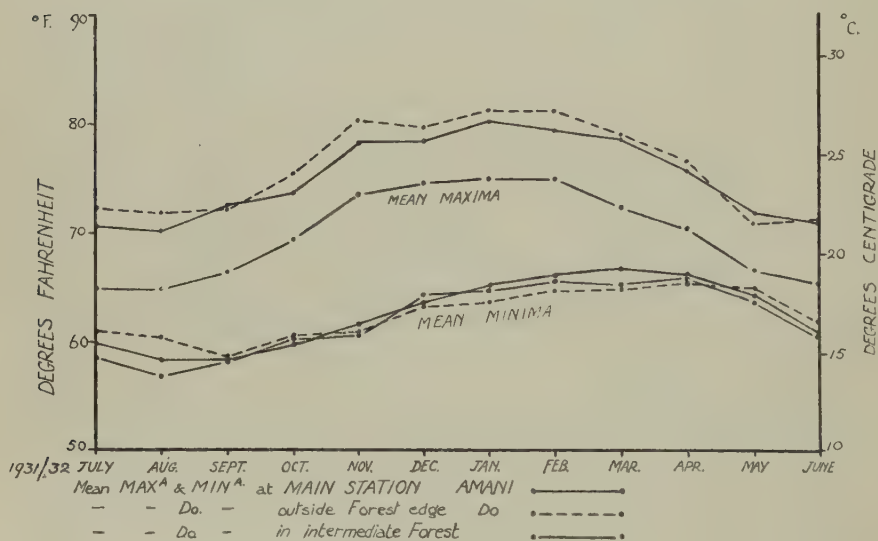


FIG. 2.

and those in the forest the difference is actually less than 1°C . in every month of the year excepting only March.)

It goes without saying that inside the forest, in a zone which is shaded from the sun by day and protected from radiation at night, the daily temperature curves are of smaller amplitude and altogether smoother than they are outside. The beginning of the rise towards the day maximum is slightly later inside the forest than outside, but the maximum is reached much later, generally not until 16.00 hours or even after that. Correspondingly, the decline from the day maximum to the night minimum tends to be much slower inside the forest than outside. A typical effect is that recorded on 6. ii. 32. The temperature remained above 20°C . for eleven hours inside as well as outside the forest; but the maximum reached in the former was only 23°C . against 27° in the latter.

Integrated into degree-hours above 20° this would give 77 outside compared with 33 inside. If we knew whether there was a temperature threshold, specific or otherwise, operative with local birds, and if so where it lay for even a single species, the records available could be utilized to work out the degree-hours above the threshold indicated. But in the absence of any biological base-line for such an operation no significant figure is attainable.

The differences in the mean monthly daily range are of interest. In this respect the Lowland Forest data are fully comparable, and they have therefore been introduced into fig. 3 as well as those appearing in the preceding figures. In the first place, within the standard climate, which with an absolute annual range of only about 20° C. would be classified as very equable, the mean

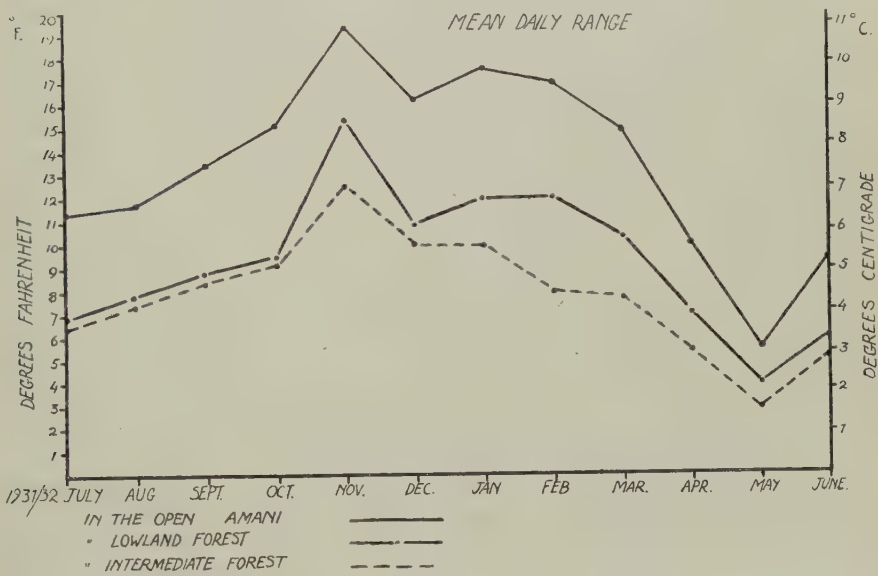


FIG. 3.

monthly daily range at the same site varies remarkably with the seasons. Outside the Intermediate Forest it is consistently above 9° C. from November to February, but in the cool wet month of May it is as low as 3° C. Inside that forest the mean daily range only once exceeds 6° C., and for April, May, and June it is under 3° , reaching a minimum of less than 2° in May. Throughout the year the daily range outside is always at least one and a half times as great as it is inside; and it is in some months practically double.

The daily range inside the Lowland Forest on the whole follows that inside the Intermediate closely and consistently. The daily range in the Lowland Forest is the greater throughout, but for eight months in the year the difference is under 1° C. At its maximum it is about 2° C. This difference is undoubtedly due to the lower and less complete canopy of the Lowland Forest.

The foregoing data permit of the following conclusions on the temperature element of the forest eco-climate :—

The potentially significant divergence from the standard climate is in the maxima and in the daily range, not in the minima. With the Intermediate Forest the differences in the maxima are actually equal to that caused by a difference of quite 2,000 ft. in altitude. During a part of the year the daily range in two different types of closed Evergreen Forest may differ by half as much as the daily range under the denser canopy differs from that in the open air.

Humidity.

In view of the probably small direct importance of humidity to birds under local conditions, no particular attention has been paid to this element of the forest climate. I say 'under local conditions' because the open-air humidity figures are remarkably high throughout the year; the mean annual humidity, as calculated from the readings at 08.30 and 13.30 hours, has been recorded as 84.4 per cent. (First Ann. Rep. East Afr. Agr. Res. Sta.). As a result, the difference inside and outside the forest is in this respect below the difference to be expected in other localities.

Hair-hygrograph records are available for the interior of the Intermediate and Lowland Forests, and for the Amani Main Station, but no atmometric data. Correctly adjusted hygrographs of the pattern used do not register above 95 per cent. R.H., and when this point is reached on the chart it is regarded as equivalent to saturation. Above 90 per cent. it is generally admitted that they cannot be regarded as accurate.

In all the circumstances it has not seemed worth while to go to the labour of calculating mean saturation deficits from the temperature and humidity figures. A useful comparison between the inside of the Intermediate Forest and the open air (Main Station) may, however, be made by taking the percentage of hours at various stages of relative humidity. During eleven months approximate saturation (i.e., over 90 per cent. R.H.) was registered both within and without the forest during about 50 per cent. of the total hours. The figures are actually 48.6 per cent. inside and 51.5 per cent. outside. This is somewhat surprising. The fact is that there are copious dews in the open on most nights in the year, and within the forest a kind of self-regulating physical sequence tends to reduce the relative humidity a little as the saturation point is approached (cf. Geiger 1927). Early in the recording it was noticed that the hygrograph inside the forest rarely showed more than 92 per cent. R.H. and never reached 95 per cent. A check of its accuracy by standard methods showed that the record must be accepted as correct.

Any difference in humidity that might be significant locally lies in the wider range outside than inside the forest. Thus, 85 per cent. of the total hours are above 80 per cent. R.H. inside the forest against 76 per cent. of the total hours outside. Inside the forest practically none of the hours below 80 per cent. R.H. are below 70 per cent. R.H.; but outside about 300 fall below 60 per cent.

Light-intensity.

There appear to be on record but few measurements of the light inside an Evergreen Forest in the tropics. Carter's (1934) are the most recent and the most satisfactory. Allee (1926), in Panama, was chiefly concerned to obtain the variations in light-intensity at particular spots, and, since there was no avoidance of sun-flecks, he records some light intensities inside the forest as high as, and even higher than, in the open.

If I had been dealing with immobile organisms I should have been interested to ascertain what proportion of the forest floor was subjected to insolation through sun-flecks, and for what part of the day individual organisms were irradiated in this manner. But for my particular purpose any attempt to compare forest with open-air light-intensities must take account of the fact that birds are mobile, and that, as a rule, those inhabiting the forest undergrowth appear to prefer shade to sun-flecks. In other words, their normal habitat is the shaded parts of the forest interior, from which it follows that it is the average shade intensity that is required in this connexion.

With this object I followed a rough and ready method which yet I believe provides a significant result. Lacking instruments for measuring light of different wave-lengths I had to confine myself to observations on the total optically active light. I used a Holophane Lumeter, which is good for the low light-intensities involved, though not adapted for the measurement of full sunshine running into thousands of foot-candles. Its principle is that the observer is able to compare the brightness of a matt white test surface, seen through the eye-piece, with that of a photometric screen carried inside the instrument and illuminated by a standard lamp also arranged in the interior. The intensity of the illumination received by the internal screen depends upon the proportion of a diffusing surface that is left uncovered by an adjustable slot. The image of the test surface appears to the observer surrounded by a ring of the illuminated screen; and when a photometric balance between the two areas is attained the light-intensity is read from the position of the slot-adjusting pointer on a graduated scale.

Movement through the undergrowth of the Amani forests is usually possible without much difficulty in any desired direction. My method was therefore to walk through the forest on an arbitrary straight line, making readings about every three paces with the test-plate held horizontal and about 3 ft. above the ground.

At first, readings were taken irrespective of the state of the sky, with a note of its condition so far as it could be seen through the tree-tops. But light-intensities in the open air change rapidly within very wide limits. Open-air records as low as 450 f.c. were obtained with lowering cloud, compared with over 14,000 f.c. (at which point the Lumeter quite failed) with an unobscured sun. It became obvious that in the absence of observations of the open-air light taken simultaneously with those inside the forest the latter were not susceptible of any comparative treatment. I therefore decided to obtain

something like standardized conditions by taking readings only when the sun was shining unobscured and within one hour of noon, and by avoiding all sun-flecks on the test-plate. Any defined bright patch was regarded as a sun-fleck. Its apparent intensity depended partly on the depth of the surrounding shade. In extreme cases a reading as low as 60 f.c. might be obtained with a visible fleck on the test-plate. But usually the reading in these circumstances amounted to hundreds if not thousands of foot-candles. As will be seen from the figures given below, the inclusion of such magnitudes would have destroyed any possibility of significant or comparable results.

Series of measurements made in the forests under the restrictions specified give the results shown in the annexed table. They are in general agreement with some hundreds of other readings made with varying states of the sky. I am indebted to Mr. L. R. Doughty for assisting in the statistical treatment of these and other data not here quoted :—

Date.	Period covered by readings.	Mean light-intensity in foot-candles.	Standard deviation.	Percentage variation.	No. of readings.
(a) <i>In Intermediate Forest :</i>					
4. 11. 31	12.15–13.00	16.3	12.9	79.5	52
5. 11. 31	12.15–13.00	16.6	9.7	60.5	50
7. 11. 31	11.00–12.00	14.2	8.6	60.6	52
(b) <i>In Lowland Forest :</i>					
12. 11. 31	11.25–12.05	25.9	10.8	41.6	47
14. 12. 31	12.00–12.50	29.4	13.1	47.0	54

Considering that the series were all taken in different areas the agreement between the means in each forest type is close, though it is to be anticipated that a wider divergence would be found if the area worked were extended. The standard deviation in each series is inevitably large. Actually a few readings were obtained of over 50 f.c. ; but under certain particularly dense patches of canopy reading after reading was obtained of under 10 f.c. While it is not desired to insist upon the mean figures given in the above table, they certainly justify the conclusion that the light-intensity in the shade of the Intermediate Forest averages a little below 20 f.c., and in the Lowland Forest a little above. As stated, I could not measure the full sunshine ; but Allee (1926) got readings of over 20,000 f.c. in Panama ; Park (1931) quotes Luckiesh to the effect that the daylight intensity in the U.S.A. is generally 10,000 f.c. on clear midsummer days, and Park himself obtained readings up to 15,000 f.c. ; Carter (1934) gives the strength of full sunlight in British Guiana as about 1.5 times that in the same latitude as Park's observations. I conclude that full sunlight in Amani must range up to about 20,000 f.c. The light-intensity I obtained for the forest shade thus averages about 0.1 per cent. of full sunlight. This compares with Carter's estimate of ' between 0.8 and 0.2 per cent.' in British Guiana.

While large numbers of readings taken simultaneously above and below the canopy at the same spot would be necessary to establish the fact, the indications from measurements made on cloudy days are that the immense disparity between the inside and outside light-intensity is diminished when the sky is obscured. Thus, with heavy cloud, ascertained later on the same morning to give open-air light-intensities below 1,000 f.c., readings inside the forest were rarely below 5 f.c. This effect is probably attributable to better diffusion of the available light under cloudy conditions.

SUMMARY.

1. The observations recorded were made with the object of ascertaining how the climatic environment of birds inhabiting the undergrowth of Evergreen Forest differs from the standard climate.
2. The temperature is more equable, with almost the same minima, but with maxima about 3° C. lower all the year round.
3. The relative humidity is not strikingly different from the standard for the locality, which is exceptionally high.
4. In shade, with all sun-flecks avoided, the visible light averages about 0.1 per cent. of full sunlight.

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On the biology of certain species of *Amauronematus* Kon. (Hymenoptera Symphyta). By HERBERT W. MILES, M.Sc., Ph.D. (Victoria University of Manchester). (Communicated by Prof. H. GRAHAM CANNON, M.A., Sc.D., D.Sc., F.R.S.)

(PLATE 7, and 3 Text-figures)

[Read 9 May 1935]

ADULT specimens of the species of *Amauronematus* Kon. are very rare in collections, an indication that they are infrequently met with in the field. This is probably due to their being, in common with certain other genera of Hymenoptera Symphyta, only a short period on the wing. Up to 1929 fourteen British species of the genus were enumerated by Perkins (7), who discovered within the limits of Devonshire several species previously unrecorded in Britain. These facts suggest that the species occurring in Britain and other European countries are far from completely known.

Still less is known of their biology, and therefore the following observations on three species, the larvae of which were found on willows, are of considerable interest. The observations are set forth in detail, and then summarised in the concluding section entitled 'General Observations'.

In the course of investigations on the insects infesting cultivated willows, it was observed that a pale green sawfly larva was numerous in beds of *Salix viminalis* L. at Mawdesley, Lancashire. Larvae were first collected in 1932, and on their emergence in 1933 the adults were identified as *Amauronematus miltonotus* Zadd. Since Enslin (3) records that nothing is known of the biology of this species and Perkins (6) notes it as 'rare on birch', observations were made on its life-history.

When collecting Lepidoptera infesting the shoots of dwarf willow, *Salix repens* L., at Formby, Lancashire, dull, yellowish-green sawfly larvae were found to be abundant. Some were collected, and when adults emerged in the following spring they were identified as *Amauronematus vittatus* Lep. Though Enslin (3) states that the larval form of this species has not been distinguished from others of the group, Cameron (2) has given a short description of it under the name of *Nematus haemorrhoidalis* Spin. It was decided, therefore, to amplify Cameron's account of the species and make further observations on the biology.

In 1933 a few whitish-green larvae were found feeding on the undersides of the leaves of goat willow, *Salix caprea* L. They emerged in 1934 and were identified as *Amauronematus perkinsi*, a new species described by Benson (1). Larvae of *A. perkinsi* have not been described and nothing is known of the biology. In appearance and habit the larvae differ from those of *A. miltonotus*

and *A. vittatus*. Biological observations are not complete, but they are included since they add to the information concerning the genus *Amauronematus*, about the biology of which there is little known.

AMAURONEMATUS MILTONOTUS Zadd.

A. miltonotus is described fully by Enslin (3). The females (Pl. 7, fig. 1) are stout, medium-sized, yellow sawflies with yellow legs and slight, variable, dark markings on the tergites of the basal abdominal segments. The wings are yellowish hyaline with the costa and stigma yellow, and have an expanse of about 15 mm. The antennae are mainly yellow, and are shorter and stouter than in *Pteronidea* Rohwer. The bluish-green egg-mass within the abdomen gives newly emerged females a greenish colour, but after egg-laying this colour is less apparent. The males are dark and slender, smaller than the females, and with a wing expanse of about 12 mm. During 1931-4 adults have been taken on the wing in June, but it seems probable that many emerge in May, since on 7 June 1933 larvae recognizable as *A. miltonotus*, and therefore in the third instar, were taken. In captivity adults emerged in the latter half of March and during the early part of April, and were placed for breeding on cuttings of *S. viminalis* that had rooted in small pots.

Mating and oviposition.—The following notes on mating and oviposition were made when a newly emerged female was isolated on the host plant. The insect emerged 9.45-10 a.m., and was immediately placed on a cutting with one large opening bud about $\frac{3}{4}$ inch in length. The insect spent the first quarter of an hour clasping the bud and cleaning head, antennae, wings, and abdomen, mainly wings and abdomen. During this time the terebra was partly exerted and the abdomen waved in a manner somewhat resembling the 'calling' of females of certain Lepidoptera. A male was then introduced on to the same plant. It had emerged two days before and had been completely inactive. In the presence of the female it became very active, vibrating the antennae, stroking the sides of the abdomen with posterior legs, and vibrating the outspread wings with great rapidity. The male then approached the female and again vibrated his wings, this time only partly outspread. The female approached the male, but the male, stimulated by sex activity, flew, and though the insects were watched for some time they were not seen to approach one another again. In the absence of the male the female remained stationary on the plant for long periods, sometimes smoothing herself with legs and antennae and then again remaining motionless. Just before 3 p.m., about five hours after emergence and when still unmated, the female began egg-laying.

Eggs of *A. miltonotus* are bright bluish green, broadest at the cephalic end and narrowly acuminate at the other. They are inserted deeply in the leaf-tissue in pocket-like incisions on the lower surface near the midrib, the cephalic end pointing towards the tip of the leaf. (Pl. 7, fig. 2.)

Oviposition was easily observed with a hand lens. The insect took up a position on the underside of the leaf, facing towards the base. The ovipositor

was pushed into the leaf-tissue until it reached the upper epidermis, then it was bent under the body of the insect in a line more or less parallel with the midrib towards the insect's left side. After a slight pause the egg passed along the ovipositor and the terebra was withdrawn. The time required for laying an egg was about half a minute.

When a number of leaves were available insects in captivity laid eggs singly or two to three per leaf. When a limited amount of leaf-tissue was available numbers of eggs were laid on each leaf. Out of doors eggs appear to be widely distributed over the host plant, since the larvae are usually found feeding singly, only one or two occurring on a shoot.

At first the eggs are most easily seen on the upper surface of the leaves. During incubation the eggs increase in size and when four days old measure about 1 mm. long and 0.4 mm. wide. The swelling of the eggs in the tissue forces the edges of the incisions apart and the eggs become partly protruded on to the lower surface of the leaves. In the final stages of incubation the eyes of the larva are clearly visible through the chorion. In the laboratory, where the day temperature during the period was 56–61° F., the eggs hatched in 12–14 days.

First instar larvae.—Newly hatched larvae measure about 2 mm. in length. They are translucent greenish except for a small bluish-green area about the fifth segment of the abdomen. The head is large and translucent and covered with short, almost transparent setae. The ocelli are black and the trophi tipped with brown. The body is long and slender and covered with short colourless setae. The thoracic legs are transparent greenish and the prolegs and pseudocerci transparent. The larvae were quite active on hatching, and wandered about the backs of the leaves before settling down to feed on the leaf-edges.

The first instar lasted 10–11 days. After beginning to feed the larvae appeared more greenish owing to the contents of the alimentary canal being visible through the integument. The bluish colour faded from the middle of the abdomen, but became apparent on the prothorax and the caudal segment. Towards the end of the first larval stadium the larvae measured 4 mm. At ecdysis the exuviae were left on the leaves near the site of feeding.

Second instar larvae.—Larvae in the second instar are dull greyish green with minute dark setae and dark pseudocerci. The head is pale greenish with a trace of bluish green along the epicranial suture. The ocelli are black and the trophi tipped with brown. The prothorax is rather bluish green, and as the larvae develop the pale dorso-lateral bands characteristic of larvae of *A. miltonotus* begin to appear. Legs and prolegs are pale translucent green. Larvae in the second instar measure up to 7 mm. in length.

The second stadium was 4–5 days. Feeding took place along the edges of the leaves as in the first stadium, and at ecdysis the exuviae were left near the feeding-site.

Third instar larvae.—Larvae in the third instar are readily recognizable

as *A. miltonotus*. They are pale translucent green with two narrow white bands extending dorso-laterally from the prothorax to the penultimate abdominal segment. The head is rather rugose and pale whitish green in colour, tinged with bluish green on the frons, along the epicranial suture, and over the occiput towards the ocelli. The ocelli are black. The antennae are flat and plate-like and the same colour as the head. The trophi are translucent green except for the brownish tips of the mandibles. The body is long, slender, and slightly flattened, especially towards the tip of the abdomen. The prothorax is pale green tinged with bluish green. From the prothorax two narrow white bands of rather irregular breadth flank the broad mid-dorsal green band. The larvae are green laterally, and the longitudinal tracheae show as a fine

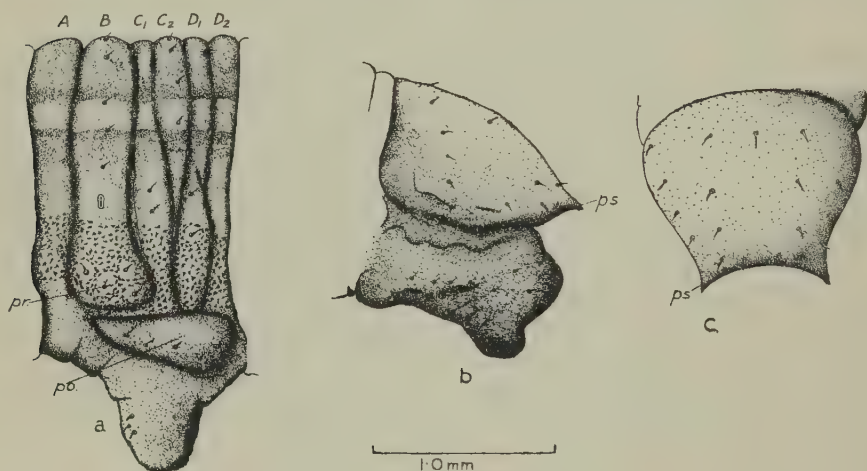


FIG. 1.—*A. miltonotus* Zadd.

- (a) 5th larval segment showing annulation (lettered according to Middleton).
pr. = pre-epipleurite. *po.* = postepipleurite. *ps.* = pseudocercus.
 (b) Caudal segment (lateral view).
 (c) Caudal segment (dorsal view).

white line connecting the spiracles. Between the spiracular line and the pale ventral surface of the body there is a rather dark smoky green subspiracular band. The thoracic legs are pale translucent green slightly tinged with bluish green and have brown tarsal claws. The prolegs are pale translucent green and, as is characteristic of the Nematini, occurs on segments 5–10 and on 13. The prolegs of the final segment appear very small and are tinged with bluish green. The pseudocerci (*ps.*) are short and almost transparent.

A typical abdominal segment of *A. miltonotus* has six annulets, the arrangement of the annulets of segment 5, lettered according to Middleton (4), being shown in text-fig. 1. Annulet A is broad and devoid of setae; B is broad and has a row of setae; C 1 and C 2 are narrow, C 1 with a few setae laterally

and C 2 with setae dorsally; D 1 and D 2 are narrow and without setae. The spiracular area is well defined. The pre-epipleurite (*pt.*) and postepipleurite (*po.*) are large and distinct and sparsely covered with setae.

Third instar larvae of *A. miltonotus* measure 8–12 mm. and feed along the edges of the leaves (Pl. 7, fig. 3). The third stadium lasts four days.

Fourth instar larvae. Larvae in the fourth instar were at first similar in appearance to those of the third instar, but were larger and measured up to 15 mm. The fourth instar lasted four days.

Fourth instar larvae fed for three days and then remained motionless on the leaves until they passed without ecdysis into the prepupal stage and were ready to enter the soil for pupation. During the quiescent period they became clear green dorsally, losing all trace of the two white stripes characteristic of third instar larvae. The broad, irregular, smoky-green, subspiracular band was still apparent, and the body was pale green ventrally. As soon as the prepupal form was assumed the larvae became very active and wandered in search of soil. During the earlier stages of larval life the caudal prolegs appeared reduced and were little used, but in the prepupal stage they function normally and appear to be the usual size.

Pupa.—The larvae enter the soil for hibernation and pupation. They construct single, tough, greyish cocoons, smooth and closely woven on the inside, and looser and with adhering soil particles on the outside. The cocoons are a peculiar shape (Pl. 7, fig. 4). The pupal chamber is oval, but at one end of the cocoon is an extension about half the width of the cocoon and nearly a quarter of its length. This extension consists of a mass of loosely interwoven strands of coarse silk without a central cavity, and its open texture probably permits the larva to remain in contact with the air during the long period spent in the cocoon. The cocoons vary in length from 9 to 11 mm., those of females being larger than those of males. Larvae remain in the prepupal stage in the cocoons from June until the following spring when pupation takes place. The adults escape through a circular exit hole cut in the broad end of the cocoon.

Annual cycle and parthenogenesis.—*A. miltonotus* is univoltine. Adults are on the wing in May and early June and larvae can be found throughout the month of June, but are only rarely taken after the beginning of July. The species hibernates in the prepupal stage in cocoons in the soil.

A. miltonotus is parthenogenetically male producing. All larvae reared in the laboratory were produced from parthenogenetic eggs, and, consequently, all data concerning the number of larval stadia refer to the development of males. Males and females occurred in approximately equal numbers among wild larvae, and it was observed that among wild larvae entering the prepupal stage some measured up to 18 mm., a much greater length than that recorded for fourth instar larvae. This seems to indicate that females attain a greater size in the larval stage and probably have an extra larval instar, as has been observed in other Nematini (5).

Host plants.—Perkins (6) associates adults of *A. miltonotus* with birch, but the writer has so far found the larvae feeding only on *Salix viminalis* L., in cultivated beds at Mawdesley, Lancashire, and Lymn, Cheshire.

AMAURONEMATUS VITTATUS Lep.

A. vittatus Lep. has been described by Cameron (2) and Enslin (3). Females are shorter and stouter than those of *A. miltonotus* and much darker dorsally. The head is yellowish, dark about the ocelli, and the antennae are dark. The thorax is striped with black, and the tergites of the abdominal segments are black except at their lateral and posterior edges. The wings are hyaline with the costa and stigma pale yellowish, and have an expanse of 13–14 mm. In life the insects are bluish green ventrally, but after egg-laying this colour is less apparent. The males are darker and more slender than the females and have dark antennae and pale yellow legs. The wings of the male have an expanse of 11–12 mm. and appear to have the stigma and costa rather darker than those of the female.

The writer has not taken adults on the wing, but since larvae almost fully grown have been taken on 14 June for two years in succession it is probable that the flight period for the species is during the month of May.

Larvae of *A. vittatus* Lep. were collected from dwarf willow, *Salix repens* L. Attempts to cultivate this willow were not successful, so when adults emerged they were offered *Salix viminalis* L. and *Salix caprea* L. growing in pots. Females isolated on *S. caprea* laid no eggs. Females isolated on *S. viminalis* laid eggs immediately, and insects transferred from *S. caprea* to *S. viminalis* began egg laying at once.

Oviposition and incubation.—Eggs of *A. vittatus* appear indistinguishable from those of *A. miltonotus*. They are bright bluish green, broad at one end and acuminate at the other, and are inserted in pockets near the midrib on the underside of the leaves. During incubation the eggs increase in size and are protruded from the leaf-tissue, and, prior to hatching, the eye-spots, tips of the mandibles, and the outline of the larval head can be seen through the chorion. In the laboratory the eggs hatched in twelve days.

First instar Larvae.—Newly-hatched larvae fed readily on leaves of *S. viminalis*, but the mortality was high, and only about a quarter of the larvae survived the first instar. They were pale green, almost transparent, with numerous, short, stout, dark setae that made them appear greyish. A dense smoky band crossed the face between the eyes. Legs and prolegs were transparent greenish and there were no pseudocerci. First instar larvae measure up to 4 mm. in length and feed along the edges of the leaves, eating out irregular portions. The first stadium lasted 10–11 days.

Second instar larvae.—In the second instar the larvae appear less greyish than in the first instar. The smoky band across the face persists, but is less dense. The larvae feed along the leaf-edges and moult near the feeding-site, leaving the exuviae on the leaves. The second instar lasts 5–6 days, and the larvae measure up to 7 mm. in length.

Third instar larvae.—In the third instar the larvae assume the appearance characteristic of the species. They are rather dull yellowish green dorsally and paler ventrally. The head is yellowish green and covered with short pale setae. On the epicranium there is a faint tinge of bluish green, and on the upper part of the frons and along the frontal sutures there are traces of brown, the remains of the smoky band crossing the face in earlier instars. The ocelli are black, the antennae are flat and brownish, and the mandibles are tipped with brown. The prothorax is bluish green. The larva is dull green dorsally with the narrow dark green dorsal vessel visible through the integument. The spiracles are connected by a well-defined white line situated in a broad pale green lateral band with darker green bands above and below (Pl. 7, fig. 5).

In *A. vittatus* the segments are separated by narrow bands of pale inter-segmental membrane. A typical segment (text-fig. 2) has six annulets, as in

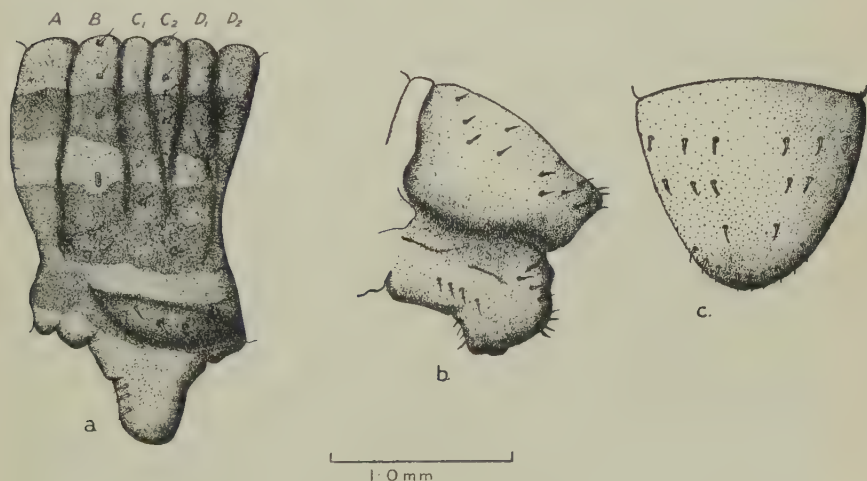


FIG. 2.—*A. vittatus* Lep.

- (a) 5th larval segment.
- (b) Caudal segment (lateral view).
- (c) Caudal segment (dorsal view).

A. miltonotus. Annulets B and C 2 each bears a row of minute black setae, and groups of minute setae occur near the spiracles and on the pre-epipleurite and postepipleurite. The setae on *A. vittatus* are rather more conspicuous than those on *A. miltonotus* and arise from small irregular areas of pigment.

Larvae of *A. vittatus* appear rather more rounded than those of *A. miltonotus*, though there is some tendency towards flattening near the tip of the abdomen, and when the larva is in a resting position the caudal prolegs appear reduced. At the ejection of frass and when the larvae wander in search of pupation sites the caudal prolegs are seen to be normal. The caudal segment has a rounded tergite bearing setae. *A. vittatus* differs from *A. miltonotus* in having no pseudocerci. The thoracic legs are pale green with brown tarsi and claws. Prolegs occur on abdominal segments 5–10 and on 13, as is usual in Nematini, and

are pale yellowish green like the ventral surface of the body. Larvae in the third instar measure up to 12 mm. in length.

The third instar lasts 3-5 days and, as in previous instars, the larvae feed along the edges of the leaves.

Fourth instar larvae.—Larvae in the fourth instar are similar in appearance to those in the third but measure up to 15 mm. in length. The fourth stadium lasts 5-7 days.

Fifth instar larvae.—Larvae of *A. vittatus* differ from those of *A. millonotus* in moulting prior to entering the prepupal stage. At the fourth ecdysis larvae of *A. vittatus* enter the prepupal stage and are uniformly clear bright yellowish green. The head is rather paler than the body and tinged with bluish green near the frontal sutures and over the epicranium. The ocelli are black and the mandibles tipped with brown. The minute black setae are no longer visible on the body, but the main lateral tracheae still show as a faint white line. The thoracic legs are pale green with dark tarsal claws and the prolegs are pale green. Shortly after entering this instar the larvae eject a few pellets of white frass. Larvae in the fifth instar remain for 2-3 days quiescent on the leaves before wandering in search of hibernation sites. No feeding takes place during this time.

All larvae of *A. vittatus* bred in the laboratory were from eggs parthenogenetically produced and were, in consequence, males. Data on larval development refer to males only. Females have been bred from wild larvae, and since wild larvae measured up to 18 mm. in length in the penultimate larval stage, it seems likely that females have five feeding instars before entering the prepupal stage while males have only four.

Hibernation and pupation.—Larvae of *A. vittatus* enter the soil for hibernation and pupation. They construct single, tough, oval, greyish cocoons of parchment-like substance with soil particles adhering to the outside. The cocoons measure 7-8 mm. in length and are 3-3.5 mm. wide, those of the females being larger than those of the males. Examination of the cocoons showed that one end was perforated with five or six minute holes resembling pinholes (Pl. 7, fig. 6). This suggests that larvae of *A. vittatus* require contact with the air during the period in the cocoon. The larvae remain in the prepupal condition in the cocoons from about the end of June onwards throughout the winter, and pupation takes place in the following spring.

Annual cycle and parthenogenesis.—There is only one generation of *A. vittatus* during the year. Adults are on the wing in May, and larvae can be found feeding until after the middle of June. Hibernation takes place in cocoons in the soil. The species is parthenogenetically arrhenotokous, that is, male producing.

Host plants.—Perkins (6) records *A. vittatus* bred from a larva on willow. Up to the present the writer has collected the larvae from dwarf willow, *Salix repens* L., only, but in captivity eggs were readily laid on *Salix viminalis*, and insects matured on this plant.

AMAURONEMATUS PERKINSI Benson.

A. perkinsi has been described recently by Benson (1). This species is smaller than *A. miltonotus* and more slender than *A. vittatus*. The head is pale yellow with the antennae darker. The thorax is striped with black rather like that of *A. vittatus*, but the black stripes are less pronounced and the general yellow colour more apparent. The abdominal tergites are black with pale yellow at the sides and posterior margins and extending forwards in the mid-dorsal line, so that in some segments the black band is almost bisected. The tip of the abdomen is pale yellow. The legs are pale yellow with brownish tarsi and claws. The wings are hyaline with the costa and stigma pale yellow and the veins darker, and have an expanse of 13–14 mm. Males are dark and slender with the tip of the abdomen pale yellowish and the legs pale. The wings have an expanse of 10–11 mm.

Adults have not been taken on the wing, but since larvae occur in June and early July it is probable that the flight period is during May.

Oviposition and incubation.—Eggs of *A. perkinsi* are indistinguishable from those of *A. vittatus* and *A. miltonotus*. They are bluish green in colour, broad at one end and acuminate at the other, and inserted into the tissue on the underside of the leaf. At first the eggs are more easily seen from the upper surface of the leaves, but during incubation they increase in size and are partly protruded from the tissue, so that they are easily seen on the lower surface. The period of incubation in the laboratory in April was ten days.

The larval stage.—At eclosion the larvae were similar in appearance to wild larvae in a later instar. They measured 2 mm. in length and wandered about the backs of the leaves before settling to feed on the leaf-edge.

Only a few eggs of *A. perkinsi* hatched in the laboratory, since many were deposited on outer leaves that dropped from the plant during the period of incubation. In the laboratory larvae did not survive the first instar; therefore no account can be given of the number of instars and the duration of the larval stadia. The descriptions are of wild larvae taken in 1933 and 1934.

Larvae of *A. perkinsi* are pale whitish green, rather flattened and with conspicuous white setae. The head is rugose, pale whitish green with a tinge of bluish green along the epicranial suture and over the occiput, and covered with short white setae. The ocelli are black, the antennae are flat and pale green, and the tips of the mandibles are brownish. The body is pale whitish green, rather broad and flattened and tapering gradually posteriorly. The prothorax is bluish green. From the prothorax to the posterior edge of the eighth abdominal segment there is a narrow dark green mid-dorsal band with a broader white band on each side. The spiracular line is white, and above and below it the body is pale whitish green. The segmentation is clearly defined by narrow white bands of intersegmental membrane. There are six annulets, as in *A. miltonotus* and *A. vittatus*, but in *A. perkinsi* annulet A bears setae. Annulets B and C 2 are large and setiferous, while C 1 is narrow and inconspicuous. In *A. perkinsi* the setae are long, white, and very conspicuous,

and arise in groups from small tubercles on the annulets and on the raised areas forming the pre-epipleurite and postepipleurite of each segment. The legs are pale translucent green with dark tarsal claws, and the prolegs are also pale translucent green. As is usual in the Nematini, the prolegs occur on segments 5-10 and on 13. The caudal segment is rather bluish green, rounded, and covered with numerous long white setae. As in *A. vittatus*, there are no pseudocerci. Mature larvae measure up to 18 mm.

The larvae were found feeding on the undersides of the leaves (Pl. 7, fig. 7) either along the edge or along a large vein, and occasionally along the petiole of the leaf. When feeding they eat out large irregular portions from the leaf-edges.

Prepupal stage.—Larvae of *A. perkinsi* resemble those of *A. vittatus* in having a moult before entering the prepupal stage, but in *A. perkinsi* the prepupal

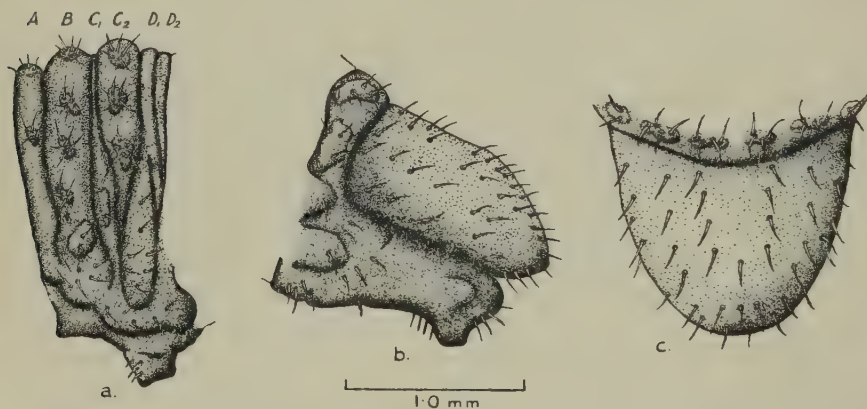


FIG. 3.—*A. perkinsi* Benson.

- (a) 5th larval segment.
- (b) Caudal segment (lateral view).
- (c) Caudal segment (dorsal view).

stage differs greatly in appearance from the feeding stages. Larvae in the prepupal stage are rounder and smoother than in the previous instars and no longer covered with conspicuous white setae. The head is pale brownish with rather denser brown on the frons. The body is whitish with almost contiguous smoky green or brownish areas. These dark areas are not well defined and vary in density, but appear to be associated with pigmentation at the bases of groups of setae. They occur on the three setiferous annulets of each segment, and since the annulets without dark areas are narrow the dark colour appears as rather broken, irregular, dark dorsal stripes. The dark coloration occurs about the spiracles and on the pre-epipleurites and post-epipleurites. No feeding takes place in the prepupal stage.

After about a day in the prepupal stage the larvae of *A. perkinsi* began to wander restlessly in search of pupation sites. Since *A. miltonotus* and *A. vittatus* hibernate in the soil, larvae of *A. perkinsi* were offered soil. Unlike the other species under observation, larvae of *A. perkinsi* refused the soil, but tunnelled into the corks of the tubes in which they were confined and into pieces of peat. Within the tunnels they constructed slight parchment cocoons about 6 mm. in length, first closing the entrance to the tunnel with dark greyish, parchment-like material with a small hole near the middle (Pl. 7, fig. 8). The cocoon usually occurred some distance from the entrance to the tunnel. The larvae remain in the cocoon throughout the winter and pupate in the following spring. Wild larvae tunnelled for hibernation 4–6 July 1933, and late larvae, collected 7–8 July 1934, tunnelled 9–15 July.

Life cycle and parthenogenesis.—Adults of *A. perkinsi* are on the wing in May, and larvae are found about the leaves of *S. caprea* during June and the early part of July. From observations in the laboratory it would seem that hibernation and pupation take place in dead wood or bark, the insect making a cocoon in the tunnel it excavates after first sealing the entrance to the tunnel.

Parthenogenesis occurs in the species, since larvae have been obtained from eggs parthenogenetically produced. Since males and females have been bred from wild larvae it seems probable that, like *A. miltonotus* and *A. vittatus*, *A. perkinsi* is parthenogenetically male producing.

Host plants.—Benson (1) records *A. perkinsi* from a larva on *Salix* in Devonshire and from a larva on *Salix* in Hampshire. The writer has taken the larvae from goat willow, *Salix caprea* L., only, and in one locality on the Lancashire-Westmorland border.

General Observations.

Biological studies provide information concerning the particular species under observation and are of considerable importance if the insect has some association with man. They also serve to throw light on the problems of classification by establishing biological relations within groups with certain common external characters, by suggesting new groupings where those in use are not satisfactory and by adding to the data available for the determination of species. Little is known of the biology of the genus *Amauronematus* Kon. Work on the adults had suggested that the genus was univoltine and largely associated with *Salix*, but the larval forms of the species were practically unknown or had not been associated with the adult insects.

From the observations recorded here it is apparent that these three species of *Amauronematus* have many common characters. The flight periods practically coincide. Egg-laying habits are similar and the eggs are identical in size and colour. The larvae of all three species feed along the edges of the leaves, though in *A. perkinsi* there is a tendency for larvae that are nearly fully grown to lie closely pressed to the under surface of the leaves while feeding at the edges. Two of the three species, *A. vittatus* and *A. perkinsi*, moult immediately before entering the prepupal stage, while larvae of *A. miltonotus* pass into the

prepupal stage without moulting. Larvae of *A. miltonotus* and *A. vittatus* enter the soil for hibernation and pupation, but larvae of *A. perkinsi* tunnel into bark or dead wood. All three species construct single cocoons of parchment-like material and make special provision for resting larvae to remain in contact with the air. Parthenogenesis occurs in the three species; two are known to be parthenogenetically arrhenotokous, and it seems likely that the third species is also male producing.

The larvae of the three species are quite distinct and can be readily recognized by their colour and appearance. The annulation seems to follow the same pattern in the three species, but the annulets show considerable variation in their relative widths, C1, D1, and D2 being very narrow in *A. perkinsi*, while in *A. miltonotus* and *A. vittatus* the segments are rather more evenly annulated. The chaetotaxy of *A. vittatus* and *A. miltonotus* is very similar, setae of *A. vittatus* being more conspicuous; but in *A. perkinsi* the setae arise in small groups instead of singly, as in the other species, and occur also on annulet A. There are marked differences in the shape of the final tergite. In *A. perkinsi* it is broadly rounded, in *A. vittatus* it is rounded but rather more sharply, while in *A. miltonotus* it is drawn out into a pair of pseudocerci. In spite of these differences in larval characters the common biological features of the three species seem to justify their inclusion in a single genus.

The writer is indebted to Mr. R. B. Benson, M.A., of the British Museum, for his assistance in identifying certain of the species, to Mrs. Mary Miles, M.Sc., for her help with the rearing of the larvae, and to Mr. Morris Cohen, M.Sc., for assistance in the preparation of the text-figures. Thanks are also due to Professor H. Graham Cannon, Sc.D., F.R.S., for his interest in the progress of the biological work.

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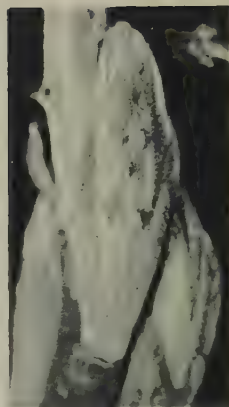
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EXPLANATION OF PLATE 7.

- Fig. 1. *A. miltonotus* Zadd. ♀. (×4·7.)
 Fig. 2. Eggs of *A. miltonotus*. (×2.)
 Fig. 3. Larva of *A. miltonotus*. (×5·3.)
 Fig. 4. Cocoons of *A. miltonotus*. (Nat. size.)
 Fig. 5. Larva of *A. vittatus* Lep. (×5·3.)
 Fig. 6. Cocoons of *A. vittatus* showing perforations. (×20.)
 Fig. 7. Larva of *A. perkinsi* Benson. (×5·3.)
 Fig. 8. Sealed entrance to hibernation site of *A. perkinsi*. (×3.)



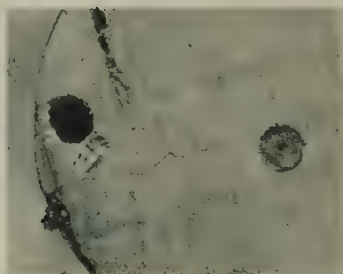
1.



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4.



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John Bale Sons & Danielsson, 154 London.

On new or imperfectly known species of Crustacea Macrura. By ISABELLA GORDON, D.Sc., Ph.D., Zoology Department, British Museum (Natural History).

(With 27 Text-figures)

[Read 9 May 1935]

INTRODUCTION.

The Crustacea Macrura described in the present paper were presented to the British Museum (Nat. Hist.) at various times by various donors, and come from regions widely separated geographically. Nevertheless, it has been deemed advisable to publish the descriptions of these new or imperfectly known forms together, rather than in several separate short reports, because of their systematic relationship. They include (1) a species of *Sergestes* of economic importance in Japan and hitherto described only in Japanese; (2) a striking new *Hippolysmata* from Madeira; (3) a small collection of Macrura, part of the Crustacea obtained by the Cambridge Expedition to British Guiana in 1933; (4) specimens of the only known Atlantic species of the genus *Anchistioides* from Bermuda.

The rediscovery of the rare *Euryrhynchus* in a pool in the Manicole swamp, British Guiana, is of special interest, because the only known specimens came from wells in South America (Pará, 1832*, and Cayenne, 1877). These specimens, four in all, were in such a poor state of preservation that no adequate account of the genus was possible.

Some attention has been given to the affinities and systematic position of the genus *Anchistioides*, which is referred to the Pontoniinae.

I take this opportunity of thanking the donors of the various specimens, whose names are mentioned under the separate species (pp. 308, 323, 339). I acknowledge also my indebtedness to Mr. C. Forster Cooper, of the Cambridge Museum, for the loan of three holotypes belonging to the genus *Anchistioides*; to the authorities of the Indian Museum, Calcutta, for the loan of a specimen of *A. compressus* Paulson; to the authorities of the Stockholm Museum for the loan of the two cotypes of *A. australiensis* Balss.; and to Prof. Ch. Gravier, of the Paris Museum, for the trouble he has taken in searching for the type-specimen of *A. seurati* Nobili and for his unfailing courtesy in answering my correspondence. I wish also to express my thanks to Dr. Kemp for placing specimens of *Sergestes* from the *Discovery* Collection, as well as his notes on the fresh material, at my disposal.

* Not described until 1907.

Family SERGESTIDAE Dana.

Genus SERGESTES H. M.-Edw.

When, several years ago, Dr. Arata Terao sent twenty specimens of a species of *Sergestes* from Japan with a request that I would compare them with the type-specimen of *S. prehensilis* Bate, I was able to confirm Hansen's statement * that they did not belong to *S. prehensilis*. The males are apparently not quite adult, yet the petasma differs markedly from, and could not represent an early stage in the development of, that of any other known luminous species.

On looking further into this question, I find that Hansen (1922, pp. 38, 121) renamed the species, referred to *S. prehensilis* by Nakazawa and other Japanese writers, *Sergestes lucens*. There appears to be no other description † of *S. lucens* than that in Japanese by Nakazawa and Terao (1915). I therefore give a short description of the species and some figures, as those in the work just referred to are on a rather small scale.

I was surprised to discover that the *Challenger* type-specimen of *S. prehensilis* also possesses luminous organs, arranged in a very different pattern from those of *S. lucens*. This led me to re-examine the arrangement of the photophores in most of the known luminous species, but the result of this study was rather disappointing. The pattern of the photophores on the ventral surface of the body proved to be very similar in all ‡, *S. prehensilis* Bate and *S. gloriosus* Stebbing excepted. And, as I will show later, these two are identical, although the *Challenger* type is said to come from off Japan and *S. gloriosus* has only been recorded from South African waters. In figs. 1 & 2 I have represented diagrammatically the arrangement of the photophores on the ventral surface of the body. *S. lucens* differs from *S. splendens* and *S. challengerii* in having four lateral pairs of photophores near the bases of peraeopods 2-5, instead of only two pairs near peraeopods 4 and 5 (α in diagrams); these are present in quite small specimens. Other slight differences shown in the diagrams are most probably due to differences in size of the specimens and not, therefore, of specific importance. It would be necessary to make a careful study of the photophores in a graded series of specimens of each species before arriving at any definite conclusions. For, in the case of *S. gloriosus* (= *prehensilis*) Dr. Kemp, who in the course of his work on board the R.R.S. *Discovery* made a careful study of the photophores in fresh material, found that the total number varied enormously according to age and size of the specimens §. The total number must vary with size in the other species

* 1919, p. 6, footnote.

† See footnote, p. 310.

‡ I have not as yet been able to re-examine *S. fulgens*, but Hansen (1919, p. 17) states that it is very similar to *S. challengerii* Hansen.

§ From 181 (or 183) in a specimen 16 mm. long to 348 (or 358) in a specimen 36 mm. long.



FIG. 1.—Pattern of photophores on ventral surface of *: a, *Sergestes prehensilis* Bate, holotype, ♂, l.=40 mm.; b, *Sergestes prehensilis* Bate, *Discovery* Expedition, St. 89, 34° 05' 15" S, 16° 00' 45" E, ♂, l.=53 mm.; c, *Sergestes lucens* Hansen, ♀, l.=34.5 mm.

* The diagram was constructed from a female specimen of *S. prehensilis* Bate in the *Discovery* collection and is a modification of that used by Kemp (1913, p. 55). In all males the fifth pair of pereopods almost meet in the middle line and the photophores at their bases are close together. In female specimens of *S. lucens* the fifth pair of pereopods are more widely separated than in *S. prehensilis*. I have, however, used the same diagram throughout. The type-specimen of *S. challengerii* has the last pair of pereopods widely separated and shows no trace of a petasma, so that it would appear to be a female, not a male as stated by Bate (1888, p. 390, St. 173).

also, though to a lesser extent, since the photophores are far less numerous. It is not advisable, therefore, to attach too much importance to slight variations in the number of the photophores on the body or the appendages of *S. lucens*, *S. splendens*, or *S. challengerii*, until much more material is available.

SERGESTES LUCENS Hansen.

Sergestes prehensilis Nakazawa, 1915, pp. 1-21, 1916, pp. 485-94 (development); Nakazawa and Terao, 1915, p. 622; Terao, 1916, p. 220 (photophores), 1917, p. 229 (photophores); Yokoya, 1933, p. 12.

Sergestes lucens Hansen, 1922, pp. 38, 121.

Sergestes phosphoreus Kishinouye, 1928, p. 125, 5 figs. (no description *).

Material.—20 specimens of both sexes, the largest males apparently rather immature.

Description.—*Rostrum* rather variable, as shown in fig. 3 *a*, with, as a rule, a small spinule behind the tooth-like apex.

Carapace, measured dorsally, exactly half length of abdomen, telson included.

Eye as represented in fig. 4 *b*, reaching to middle of basal antennular segment. Eye-stalk considerably widened distally, bearing two photophores on the inner surface; cornea much wider than stalk.

Antennular peduncle very similar in both sexes †; second and third segments subequal, about two-thirds as long as, and much narrower than, the basal segment. Inner flagellum of male as represented in fig. 5 *b*.

Antennal scale as represented in fig. 6 *b*, with three photophores.

Mouth-parts as represented by Nakazawa and Terao (1915, plate, figs. 5-9); mandible and second maxilliped represented in fig. 4 *c* & *a*, for comparison with those of *S. prehensilis* Bate. Proximal segment of mandibular palp more slender than in *S. prehensilis* and a photophore present, near the base of the palp, on the mandible itself.

Peraeopods 1, 2, and 4 are figured by Nakazawa and Terao (1915, plate, figs. 10-13). I have only observed one of the photophores on peraeopod 1, namely that on the merus; if one is present near the distal end of the carpus it must be small and indistinct. It may be that the specimen examined by Nakazawa and Terao was larger (see p. 308) or that some of the photophores, though distinct in fresh material, are not very conspicuous in specimens preserved for some years in alcohol.

In peraeopod 3 there are three photophores, two on the ischium, one distal and one proximal, and one at the distal end of the merus. Peraeopod 4 has

* It is almost certain that *S. phosphoreus* Kishinouye is this species, since he refers to it as follows:—‘In our waters *Sergestes phosphoreus* Kishinouye and *Acetes japonicus* Kishinouye are caught commercially, and some species of *Lucifer* are abundant in the warm current, Kuroshiwo.’ I have not succeeded in tracing any earlier reference to this specific name, and in 1933 Yokoya still refers to *S. prehensilis* Bate.

† i.e. no spinose projections at distal end of third segment of male, cf. *S. fulgens* and *S. challengerii* Hansen, 1919, pl. 1, figs. 4 *c*, 6 *c*,

two photophores on the ischium; pereopod 5 one only, near the distal end of the ischium.

Uropod as represented in fig. 6 *a*, with four photophores.

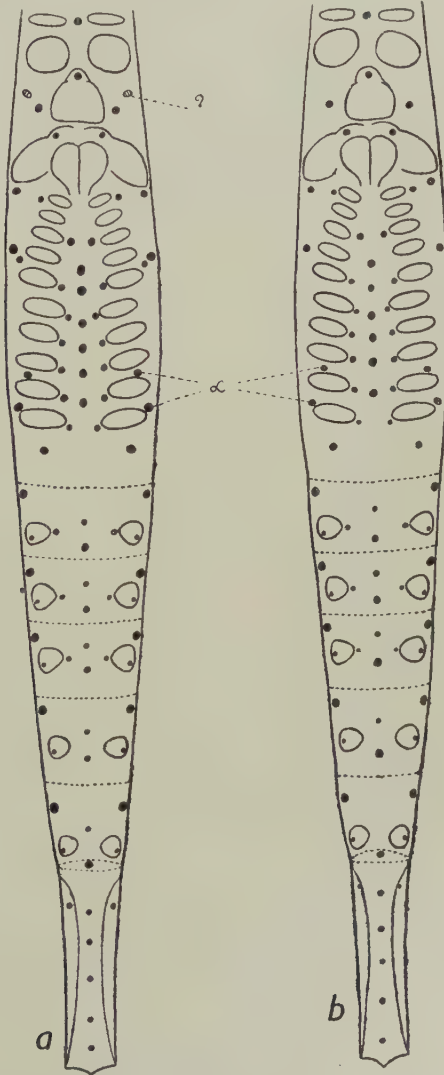


FIG. 2.—Pattern of photophores on ventral surface of: *a*, *Sergestes splendens* Hansen, *Discovery* Expedition, St. 280, 00° 36' S., 8° 28' E., ♂, l.=42 mm.; *b*, *Sergestes challengerii* Hansen, holotype, ♀, l.=24 mm.

Petasma very characteristic (fig. 5*a*) and, although probably not fully developed, cannot be regarded as an early stage of that of any other luminous species.

The *branchiae* agree in number and arrangement with those figured for *S. challenger*i by Illig (1927, p. 299). The thoracic sternite of the female between peraeopods 3 and 4 is represented in fig. 7.

Photophores.—Terao (1917, p. 300) has published a list of the photophores observed by him, and has also described the manner in which they function in the living animal. In diagram c, fig. 1, the photophores present in a specimen measuring approximately 35 mm. in length are shown. They differ somewhat in number and arrangement from Terao's list—e.g. there are four instead of six on the sternite between the bases of the fifth peraeopods and two



FIG. 3.—a, *Sergestes lucens* Hansen, rostrum; b, *Sergestes prehensilis* Bate, holotype, ischium and merus of third peraeopod; c, ditto, ischium and merus of second peraeopod. $\times 12$.

instead of one on the third abdominal sternite. These variations may be due to differences in size of the specimens or may represent individual peculiarities (see p. 308). On the sixth abdominal segment there are either 4 or 5 on the mid-ventral line.

The presence of four lateral pairs of photophores between peraeopods 1–5 would appear to be characteristic of *S. lucens*, as they are present even in much smaller specimens. In *S. splendens*, *S. prehensilis*, and *S. challenger*i only the posterior two pairs are present (α in diagrams, figs. 1 & 2).

Remarks.—This species can easily be distinguished from *S. prehensilis* Bate by the pattern of the luminous organs on the ventral surface of the body, notably on the abdomen and on some of the appendages (cf. diagrams *c* & *a*, fig. 1; also figs. 4, 6, & 8). The petasma and inner flagellum of the antennule also differ markedly in the two species (cf. figs. 5 & 9).

The petasma distinguishes this species from all the other luminous forms.

According to the English abstract * sent out by Nakazawa with his reprint, *S. lucens* is of great economic importance in Japan. The total weight caught annually is about 10 million lb., worth some half a million yen. The specimens are boiled and dried immediately they are brought ashore; they are regarded

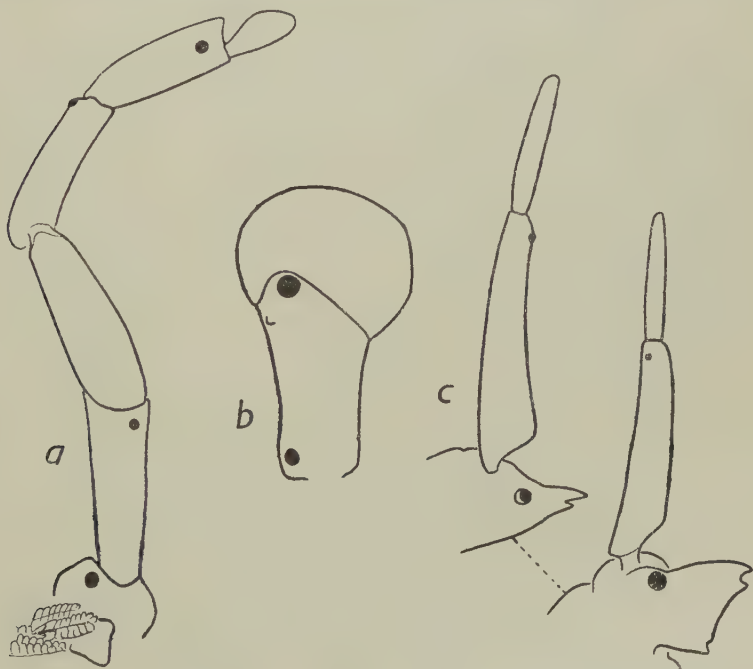


FIG. 4.—*Sergestes lucens* Hansen. *a*, second maxilliped, $\times 16$; *b*, eye; *c*, mandible with palp. *b* & *c*, $\times 20$.

as a great delicacy and are exported to China and other countries. With regard to its habits Nakazawa states that during the day it lives on the bottom (depth not stated) and feeds on the micro-organisms and organic substances contained in the mud. At night it rises to mid-water in winter, to near the surface after May, when it is fished in great quantities about two miles off shore in the vicinity of Mt. Fuji†. The ovaries and the ova are of a greenish-grey colour; the ova

* Abstract not published in his paper; see, however, Stebbing, 1916, 'Knowledge,' London, xxxix, p. 108.

† The nets are lowered to depths of 50 to 100 fathoms.

float freely in the water, being more numerous in deeper water; he figures a number of larval stages.



FIG. 5.—*Sergestes lucens* Hansen, ♂. *a*, petasma, $\times 36$;
b, inner flagellum of antennule, $\times 48$.

SERGESTES PREHENSILIS Bate.

Sergestes prehensilis Bate, 1888, p. 385, pl. 71; Hansen, 1903, p. 56, pl. xi, figs. 4 *a*, 4 *b*.

Sergestes gloriosus Stebbing, 1905, p. 84, pls. 22 & 23; Hansen, 1925, p. 24.

Nec *Sergestes prehensilis* of Japanese authors (= *S. lucens*) *.

Remarks.—It is rather surprising that Hansen failed to observe the numerous

* Probably not the *S. prehensilis* of Nobili (1906, p. 22); no mention is made of photophores, and *S. bisulcatus* Stebbing, with which it is compared, has none.

photophores of the type-specimen of *S. prehensilis* when he re-examined the *Challenger* material in 1903. They are, it is true, not nearly so clear as those of the type of *S. challenger* Hansen, but are quite distinct under magnifications

FIG. 6.

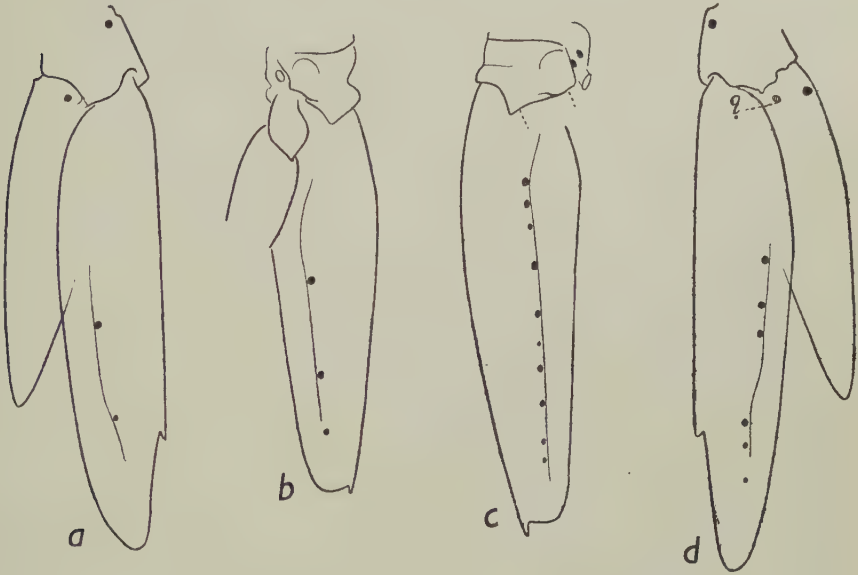


FIG. 7.

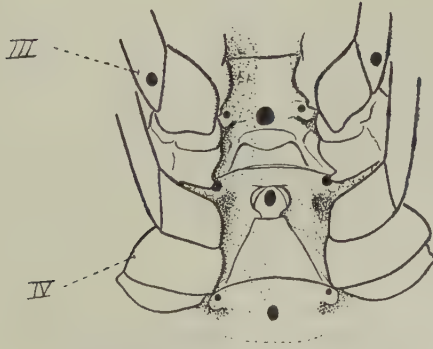


FIG. 6.—*Sergestes lucens* Hansen : a, uropod ; b, antennal scale. *Sergestes prehensilis* Bate, holotype : c, antennal scale ; d, uropod. All $\times 10$.

FIG. 7.—*Sergestes lucens* Hansen. Part of thoracic sternite of female, $\times 16$. III & IV, pereopods 3 and 4 respectively.

of 16–24. The holotype of *S. prehensilis* is now in poor condition and not quite complete ; the thoracic sternite anterior to the first pair of pereopods has been destroyed by removal of the mouth-parts on one side. The arrangement of the photophores on the ventral surface of the body, as far

as can be ascertained, is as represented in fig. 1*a*. The pattern is obviously quite distinct from that of *S. lucens* Hansen (fig. 1*c*), a species erroneously referred to *S. prehensilis* by Japanese carcinologists. (The photophores (?), shaded in the diagrams, are indistinct.)

The distribution of the luminous organs on the appendages of *S. prehensilis*, holotype, is as follows :—

Antennular peduncle	? 1 at distal end of third segment. 2 on proximal third of lower inner margin of first segment*.
Antenna	2 on basal segment. 10 on scale (fig. 6 <i>c</i>).
Eye-stalk	1 near cornea (fig. 8 <i>b</i>).
Mandible	1 at distal end of first segment of palp (fig. 8 <i>a</i>).
Second maxilliped	2 as represented in fig. 8 <i>c</i> .
Third maxilliped	3 (at distal end of merus, carpus, and propodus respectively). ? 1 on basal segment.
First peraeopod	? [appendage missing].
Second peraeopod.....	3 as represented in fig. 3 <i>c</i> .
Third peraeopod	11 as represented in fig. 3 <i>b</i> .
Fourth peraeopod.....	? [appendage missing].
Fifth peraeopod	? [appendage missing].
Pleopods	1 externally on basal segment of each.
Uropod	1 on peduncle. 1 (? 2) on endopod 6 on exopod (fig. 6 <i>d</i>).

The short row of photophores usually present above the posterior part of the branchial chamber has not been observed; there is a row of 13 lower down on the branchiostegite parallel with the lower border as in *S. gloriosus* Stebbing.

The arrangement of the photophores described above agreed so closely with that of *S. gloriosus* as to suggest that the two species might be identical. I have not examined the type-specimens of *S. gloriosus*, but, on comparing the female determined by Hansen (1925, p. 24) and specimens of unusually large size in the *Discovery* collection†, it was evident that they were co-specific with *S. prehensilis*. The holotype is a rather immature male, but already most of the photophores on the ventral surface of the body are present (*cf.* figs. 1*a* & *b*). The petasma is obviously a rather early stage of that represented in fig. 9*c*, and already most of the terminal lobes are present as small buds (*cf.* fig. 9*a*).

S. prehensilis differs from all the other luminous species that I have examined as follows :—(1) there is no photophore on the labrum or on the mandible itself; (2) there is a longitudinal row of photophores on the antennal scale, exopod of uropod, merus of third praeopod, and a series of 13–19 or 20 on the

* Hansen (1925, p. 25) was unable to detect the four photophores stated by Stebbing (1905, p. 85, pl. 22, fig., *a.s.*) to occur on the proximal segment of the antennular peduncle of *S. gloriosus*. These photophores are present, although they vary somewhat in number; in the specimen determined by Hansen there are two on the proximal third and one at the distal end of the lower inner margin. In the *Discovery* material there is also one near the apex of the stylocerite in some specimens, at least, and occasionally three on the proximal half of the lower inner margin.

† Determined by Kemp; not yet reported on.

branchiostegite as well as a row of minute ones on the pleura of the sixth abdominal somite ; (3) the long transverse streaks of 1-3 photophores on each of the first four abdominal somites is very characteristic. The photophores are, moreover, about twice as numerous, in adults, as in any other species.

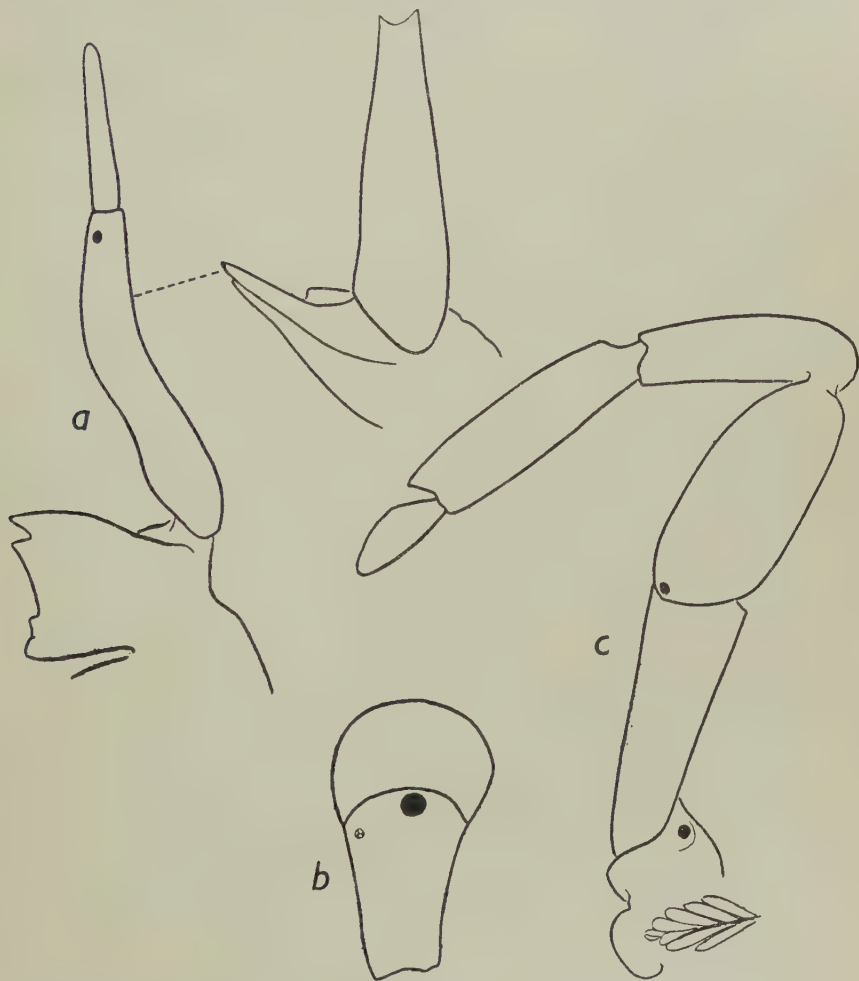


FIG. 8.—*Sergestes prehensilis* Bate, holotype: *a*, mandible with palp; *b*, eye; *c*, second maxilliped. *a* & *b*, $\times 20$; *c*, $\times 16$.

Distribution.—The type is stated by Bate to have been taken off Japan, but the species has not been rediscovered in the Pacific. *S. gloriosus* was first recorded from the Eastern coast of South Africa (Stebbing, 1905, p. 87) and was later rediscovered off the coast of Natal (Hansen, 1925, p. 24). Recently numerous specimens have been obtained by the *Discovery* Expedition off the Atlantic coast of Cape Colony.

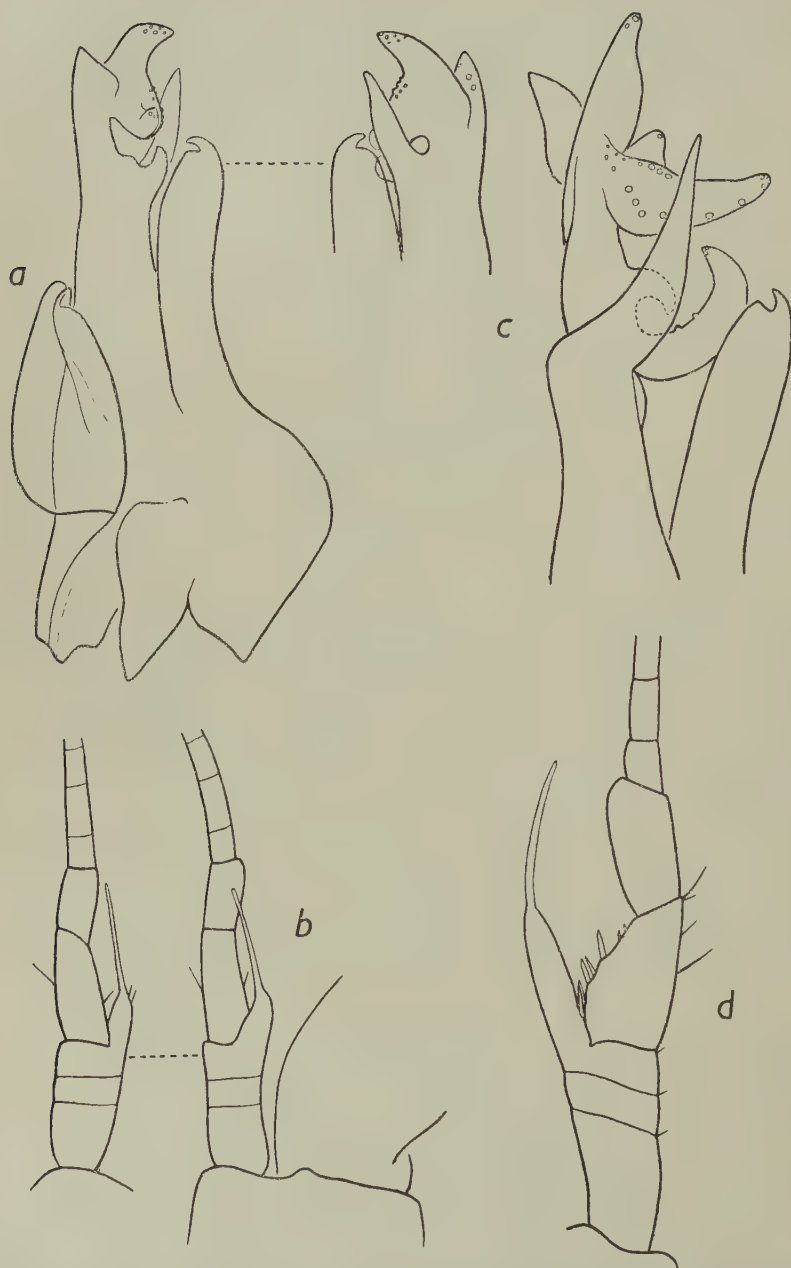


FIG. 9.—*Sergestes prehensilis* Bate, ♂. Petasma: *a*, of holotype; *c*, of larger specimen, *Discovery* Expedition, St. 405: $\times 36$ & 40. Inner flagellum of antennule: *b*, of holotype; *d*, of larger specimen: $\times 48$.

Family HIPPOLYTIDAE Ortmann.

Genus HIPPOLYSMATA Stimpson.

HIPPOLYSMATA GRABHAMI, sp. n.

Material: 1 ovigerous ♀, holotype (l.=68 mm.), from Funchal, Madeira; presented by the late Dr. M. Grabham*.

Description.—*Rostrum* scarcely reaching to distal end of second antennular segment, straight and rather narrow, about three-fifths dorsal length of carapace. It is continued posteriorly as a low carina, which ends about 6 mm. from the posterior margin of the carapace. Rostral formula $\frac{(1+1)+4}{4}$, the posterior spine on the carapace is 5 mm. behind the anterior one, which is just behind the posterior border of the orbit (fig. 10).

Carapace, measured dorsally from orbital border, almost exactly half length of abdomen excluding the telson. Antennal spine much larger than that at the pterygostomial angle.

Antennule.—Peduncle scarcely exceeding antennal scale; relative lengths of segments approximately 3.5 : 2 : 1. Upper flagellum not divided, the first 34–35 segments rather thickened and slightly setose. The flagella at least four times as long as carapace, but probably incomplete. Stylocerite lateral to basal segment, reaching a short distance beyond the eye.

Antenna.—Scale long and rather narrow, the length approximately 3.5 times the greatest width; the short spine scarcely exceeds the rounded apex. Flagellum at least half as long again as body, but probably not complete. A short spine on the segment bearing the scale.

Eye.—Corneal part not much wider than the stalk, colour greyish black.

Mouth-parts.—Mandible of the usual type, without palp or incisor process; on the inner side is a low narrow plate with margin faintly trilobed, the median lobe being shortest (fig. 11 b). On the anterior margin of the broad spinuliferous area (shaded) is a similar, much shorter, faintly bilobed plate, subparallel to the inner one. Maxilla on left side normal, with distal endite broad and bilobed; that on right side abnormal, with the distal endite narrower and simple. First maxilliped as represented in fig. 11 a. Third maxilliped

* 21. 8. 35. Today I received six additional specimens (5 ovig. ♀♀, 1 ♂) from Mrs. E. B. Carter. The rostrum is more slender in some of the specimens than in the holotype; rostral formula $\frac{(1+1)+3-4}{4-6}$. The telson is nearly as long as the endopod of the uropod and has a series of uniformly graded setae on the distal three-fifths of each lateral margin; the anterior pair of dorsal spines is at the middle; there are two pairs of spines and a pair of long median setae on the posterior margin. The antennular and antennal flagella are at least six times as long as the carapace. The male (l.=60 mm.) is smaller and more slender than the females; the endopod of the first pleopod is shorter and much narrower than the exopod, without appendix interna; the appendix masculina is subequal to the appendix interna of the second pleopod and bears four long terminal setae; there are only 17–18 segments in the carpus of the second pereopod.

exceeding antennal scale by most of the ultimate segment, exopod reaching to about middle of antepenultimate segment; the numerous setae almost conceal the short spines on the distal segment, which terminates in three stout blunt spines.

First peraeopods equal, surpassing antennal scale by most of the chela; merus, carpus, and chela subequal, dactylus rather more than half as long as palm; when closed there is a narrow gap between the fingers. In addition to the few long setae on all the segments, there are two series of shorter setae on the distal third of the inner surface of the carpus and tufts of short setae on the fingers.

Second peraeopods slender and unequal; the larger on the left side exceeds

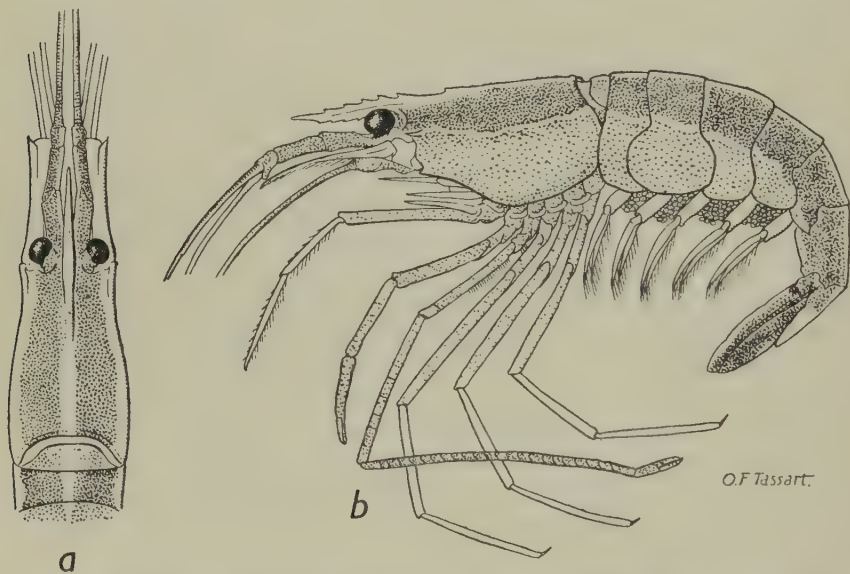


FIG. 10.—*Hippolysmata grabhami*, sp. n., holotype: *a*, anterior part of body in dorsal aspect; *b*, lateral aspect, to show colour. Heavy stippling, red; fine stippling, translucent yellow; unshaded, white or translucent white. $\times 1.33$.

the antennal scale by the distal fifth of the merus, carpus, and chela. There are 23 subdivisions in the carpus, the distal one being almost as long as the palm and equal to the sum of the three preceding joints. Merus indistinctly 7-segmented, a single faint suture near distal end of ischium, which has a series of about 24 curved spinose setae on proximal half of ventral margin. Movable rather shorter than immovable finger, and rather longer than palm; fingers when closed separated almost throughout their length by a narrow gap. Right peraeopod more slender and rather shorter than left, but with the same number of subdivisions in carpus, merus, and ischium; fingers equal and of same length as palm; only about 18 curved setae on ischium.

Third praeopod exceeding antennal scale by distal half of carpus, propodus, and dactylus—the *fifth peraeopod* by distal half of propodus and dactylus. All three dactyli are very short, subequal, and armed on ventral margin with 4 spines, the last being almost as long as the terminal claw. Each propodus

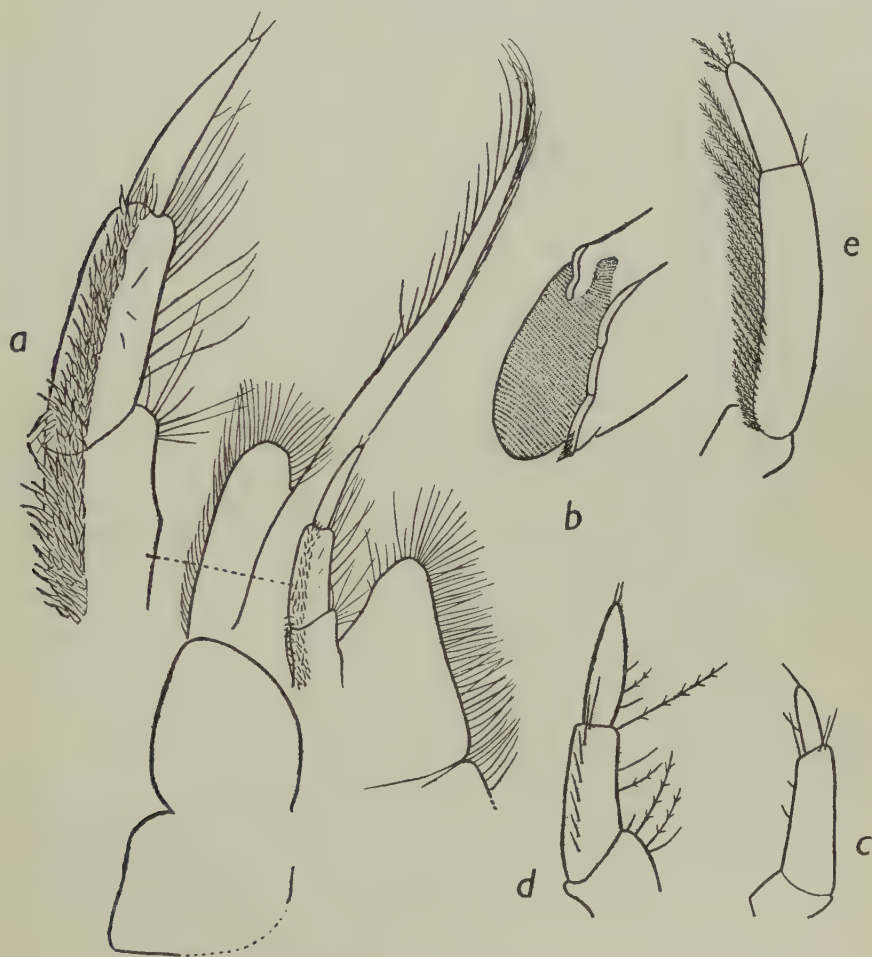


FIG. 11.—*Hippolysmata grabhami*, sp. n., holotype: *a*, right first maxilliped, with endopod further enlarged, $\times 12$ & 30 ; *b*, right mandible, molar process, $\times 30$. Endopod of first maxilliped of: *c*, *Hippolysmata multiscissa* Nobili; *d*, *Hippolysmata vittata* Stimpson (type of *Nauticaris unirecedens* Bate); *e*, *Hippolysmata wurdemanni* (Gibbes): $\times 48$.

has a ventral series of 10–15 short spines, those near the distal end gradually increasing in size. There are 5–6 ventral spinules on each carpus and 2–5 spines on the outer surface of each merus.

Epipods at base of external maxilliped and peraeopods 1-4 large and not concealed by the pleurobranchs, bifid posteriorly. Sixth segment of *abdomen* nearly half as long again as fifth (1.4 : 1).

Telson incomplete distally; the proximal pair of dorsal spines placed at a considerable distance from the base.

The left *uropod* also lacks the exopod, although it has been inserted in fig. 10 *b*.

The *ova* are of small size and the embryos are in an advanced stage of development.

Colour (fig. 10).—The specimen was preserved in weak formalin and a note made of the striking colour-pattern immediately after its receipt.

Most conspicuous are the two broad dorso-lateral bands ($w.=2.5-5$ mm.) of a brilliant red extending along the entire length of the body (heavy stippling). They are separated by a mid-dorsal narrow stripe of white, rather opaque anteriorly, more translucent posteriorly ($w.=1-2.5$ mm.), and from the translucent yellow of the rest of the body by a translucent white edging. The red is continued anteriorly on to eye-stalk, peduncle of antennule, and for a short distance along each of the three long flagella; posteriorly on to uropods and for a short distance on to the telson. The rostrum, main part of each feeler, and the distal two segments of the external maxillipeds are white. The peraeopods tend to become a translucent white distally, but in the second pair the yellow is deepened to a reddish orange on carpus and chela. The peduncles of the pleopods are translucent white, as also is the main portion of the telson, outer border of exopod, and median half of inner border of endopod of uropod.

Remarks.—This fine specimen is much larger than most of the known species of *Hippolysmata*, which are under 35 mm. in length. Only the few species with long crested rostrum exceed 60 mm. in length, and they are referred by some authors to a distinct genus *Exhippolysmata* (e.g. Stebbing, 1915, p. 94; Balss, 1933, p. 85) *.

Apart from size and colour, however, *Hippolysmata grabhami* does not agree with any of the Atlantic, or indeed with any of the known, species, as far as one can judge from the descriptions, which are frequently most inadequate. Two of the Atlantic forms, *H. moorei* Rathbun and *H. intermedia* Kingsley, belong to the genus *Lysmata* (Kemp, 1914, p. 112) and perhaps also *H. wurdemanni* (Gibbes), which is a transitional form. In two ovigerous females in the British Museum Collection† the basal thickened portion of the upper antennular flagellum is heavily setose and is divided distally for a short distance (7.7 : 1 being the ratio of fused to free parts). *H. wurdemanni* further differs from the Madeira species in colour being red and translucent white, and in the greater number of subdivisions (47) in the carpus of the second peraeopod.

* See also Kemp, 1916, p. 401; he does not consider the differences sufficient to justify generic distinction.

† These specimens were purchased from the Smithsonian Institution and determined by Stimpson.

H. rhizophorae Rathbun, from Brazil, has much shorter antennular and antennal flagella, a distal spine on the propodus of the third maxilliped, and a shorter second pereopod*.

The mouth-parts have not been described in any great detail in the majority of the species. In *H. grabhami* the distal endite of the right maxilla is simple, but this is probably an abnormality, for the endite on the left side is much broader and divided, as in the other three species represented in the British Museum Collection. The endopod of the first maxilliped, however, differs appreciably in all the species that I have been able to examine†. In *H. wurdemanni* and *H. multiscissa* the ultimate is only about half as long as the penultimate segment, while in the former there is a characteristic series of plumose setae (cf. fig. 11*e* & *c*).

The ultimate segment is nearly, or quite, as long as the penultimate in *H. vittata* and *H. grabhami*; in the latter there are numerous soft setae, each much expanded proximally, arranged in some 3-4 rows as represented in fig. 11*a*; in the former there is a single series of about 8 setae (fig. 11*d*). Of *H. marleyi* Stebbing (1919, p. 120) states that 'the other mouth-organs are in near agreement with those of the species just mentioned (i.e. *Exhippolysmata tugelae*), but not showing the small conical joint at the apex of the endopod in the first maxilliped'. Does this imply that the ultimate segment is wanting, or that it is of good length as in the case of *H. grabhami* or *H. vittata*? In *E. tugelae* the ultimate is only about one-third of the penultimate segment (Stebbing, 1915, pl. 89, *mxp.* 1). When a revision of the species of *Hippolysmata* is undertaken a careful study of the mouth-parts would seem to be essential.

Family PALAEMONIDAE Bate.

Subfamily PALAEMONINAE Kingsley.

The following Palaemonid species are represented in Dr. Carter's collection from British Guiana:—

Palaemon amazonicus Heller.

— *braziliensis* Heller.

— *jamaicensis* (Herbst).

— (*Macrobrachium*) *olfersi* Wgm. ?—immature specimens.

Palaemonetes carteri, sp. n.

Euryrhynchus wrzesniewskii Miers.

The last two forms in the list are described below.

* Reaching only to end of third maxilliped (Rathbun, 1900, p. 153); in *H. grabhami* the carpus exceeds this maxilliped by five-sixths of its length.

† *H. wurdemanni* det. by Stimpson, *H. vittata* (type of *Nauticaris unirecedens* Bate), and *H. multiscissa* det. by Balss,

Genus *PALAEMONETES* Heller.*PALAEMONETES CARTERI*, sp. n.

Material.—No. 28 (or 25), 6. v. 33. Karow Creek, 2 m. N.E. of Penal Settlement, Mazaruni, 1 ♂.

No. 390, 11. vii. 33. River Cuyuni, Camp 1, 1 ovigerous ♀.

No. 397, 11. vii. 33. Forest Swamp, near Camp 1, Upper Cuyuni, 1 ♂.

No. 416, 12. vii. 33. Creek near Camp 1, Upper Cuyuni, 8 ♂♂ (including holotype), 4 ♀♀ (one ovigerous), 1 juv.

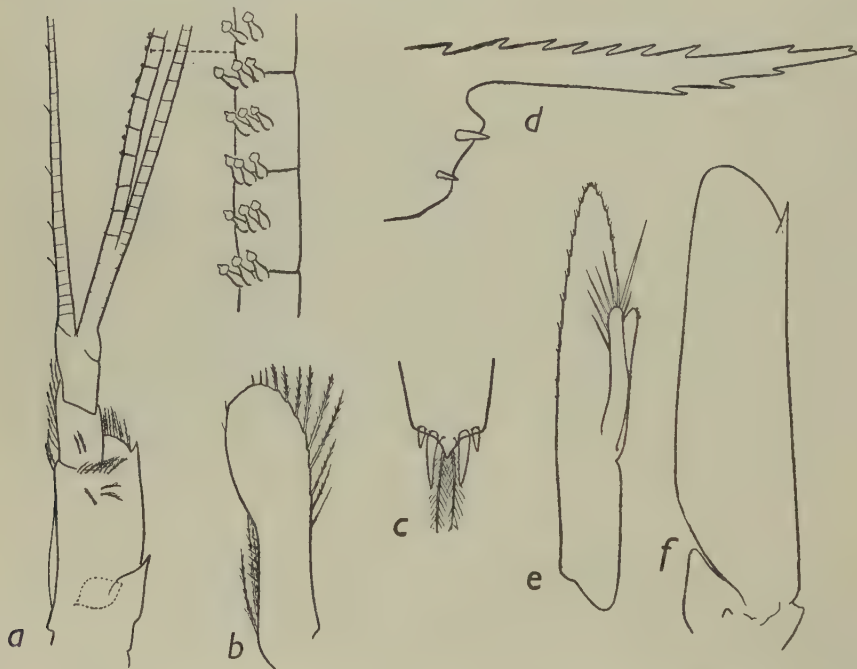


FIG. 12.—*Palaemonetes carteri*, sp. n., paratype, ♂ (l. = 24 mm.): *a*, antennule, with portion of accessory ramus of outer flagellum greatly enlarged, $\times 12$ & 45 ; *b*, endopod of first pleopod, $\times 27$; *c*, end of telson, $\times 27$; *d*, rostrum, $\times 9$, the second spine from apex usually absent; *e*, endopod of second pleopod, $\times 27$; *f*, antennal scale, $\times 12$.

Description of holotype (♂, l. = 28 mm.). *Rostrum* long, slender, and very slightly upturned in distal third; rostral formula $\frac{1+5+1}{4}$, the dorsal series ends some distance from the bifid apex leaving the distal third unarmed, the ventral series commences below the fifth dorsal spine (that on carapace included) and is thus restricted to the distal half of the lower border (fig. 12 *d* is unusual in having a dorsal spine a short distance behind the bifid apex).

Branchiostegal spine situated near to, and projecting slightly beyond, the antero-lateral margin of the carapace,

Antennule tiramous. Accessory ramus of outer flagellum rather thick and of considerable length; the short fused portion is one-fifth of the free part which is divided into some 17–19 segments. On each of these segments, the proximal two or three excepted, are two short rows of special spines of the type represented in fig. 12*a* on the inner inferior margin. There are 1–4 spines in each row in the holotype; in the paratype figured three is the usual number. The fused basal portion probably consists of some 5–7 segments, but the sutures are very indistinct.

Antenna.—Scale as long as rostrum, rather narrow and of almost uniform width in the distal two-thirds. The rounded apex projects well beyond the subterminal spine (fig. 12*f*).

Mouth-parts.—Normal; mandible without palp, three sharp teeth at apex of incisor, and 5–6 rounded lobules at apex of molar, process. Third maxilliped slender, reaching to distal end of proximal segment of antennular peduncle; exopod as long as antepenultimate segment of endopod; segments of the latter in the proportions of 1.4 : 1 : 0.77.

First peraeopods slender, extending to distal end of antennular peduncles and not quite to end of antennal scale. Carpus rather longer than merus and almost twice as long as chela; fingers rather longer than palm.

Second peraeopods equal, slender, extending a short distance beyond antennal scale; merus subequal to chela, fingers six-sevenths of palm; ratio of carpus to chela 1.62 : 1.

Third peraeopod reaching to distal end of antennular peduncle; the propodus almost two and a half times as long as dactylus. *Fifth* peraeopod extending to apex of antennal scale; propodus three and a half times as long as dactylus, with 7–8 short rows of setae or spinules on distal third of ventral margin.

Abdomen, excluding telson, almost three times the length of the carapace (measured dorsally from orbital border); sixth segment and telson subequal.

Pleopods.—No appendix interna on the endopod of first pleopod (fig. 12*b*); the two appendices of second pleopod of equal length (fig. 12*e*).

Telson.—Rather shorter than endopod of uropod, although the feathered setae reach almost to its posterior margin. End of telson as represented in fig. 12*c*. The anterior pair of spines on the dorsal surface situated at middle, the second midway between first pair and the end of the telson.

Female.—Very similar to, although rather larger and more robust than, the male. In addition to the usual sexual differences exhibited by the pleopods and the position of the genital openings, the accessory ramus of the outer flagellum of the antennule is shorter and more slender. The free is only about two and a half times as long as the fused portion, and consists of some 8–9 segments; there are only one or two of the special spines in each row on the inner inferior margin (*cf.* fig. 12*a*).

The carpus of the second peraeopod is longer relatively to the merus (1.72–1.90 : 1) and the limb extends beyond the antennal scale by at least the entire chela.

The ova are rather large ($1.60-1.65 \times 1.10-1.15$ mm.) and number about 22-24; they are cemented to the long setae on the peduncles of the first three pairs of pleopods and are also well protected laterally, and to some extent ventrally, by the large pleura of the first three abdominal somites, but the pleopods are not appreciably reduced in size (cf. *Euryrhynchus*).

Remarks.—The rostral formula varies somewhat ($\frac{1+4-7+1-2}{3-6}$); four is the usual number of spines in the ventral series occurring in eleven of the sixteen specimens; beyond the distal unarmed portion on the dorsal margin there are invariably one or two subterminal spines, so that the apex may be described as bifid (9 specimens) or trifid (7). The rostrum also varies considerably in length and may be rather shorter or longer than the antennal scale.

The pair of plumose setae at the end of the telson is occasionally wanting, sometimes there are three such setae. The second peraeopod in the male usually exceeds the antennal scale by the length of the fingers, rarely by as much as the entire chela.

This species is nearest to *Palaemonetes sinensis* Sollaud, according to the key to the species given by Kemp (1925, pp. 315-17), since the outer antennular flagellum has the fused part less than one-third as long as the free part of the shorter ramus in the male and less than half as long in the female. The species may be inserted in the key as follows (p. 316):—

GGG. Outer antennular flagellum with fused part less than one-third as long as free part of shorter ramus, at any rate in the male.

H. First maxilliped normal, rostrum with apex bifid or trifid and distal fourth of upper margin unarmed as a rule. *carteri*, sp. n.

HH. First maxilliped modified (with two distinct endites), rostrum with dorsal teeth extending almost to the apex, which is simple *sinensis* Sollaud.

Genus EURYRHYNCHUS Miers.

Miers, 1877, p. 662; Calman, 1907, p. 295; Kemp, 1925, pp. 285 (in key), 286.

The genus *Euryrhynchus* was established by Miers in 1877 for the reception of *E. wrzesniowskii*, of which he had only two imperfect specimens from a well in Cayenne. A second species, *E. burchelli*, was described by Calman in 1907, also from two dried, rather incomplete specimens from a well in Pará. Owing to the fewness of the specimens and their poor state of preservation, it was not possible to give an adequate description of either species.

In 1933 Dr. Carter collected over fifty specimens from the Manicole Swamp in Upper Cuyuni, British Guiana, and these proved to belong without doubt to *E. wrzesniowskii*, one rather fragmentary cotype of which is still in the British Museum Collection. It may be that the type of swamp from which so many specimens were taken is the more usual habitat of this interesting form, and yet it is a remarkable coincidence that, on two previous occasions, specimens of the genus were found in wells,

The genus has been referred to the subfamily Palaemoninae because the outer flagellum of the antennule is divided throughout its entire length. The gill-formula proves to be in agreement with that of *Palaemon* and the other genera of the Palaemoninae. *Euryrhynchus* would appear to be most closely related to Dana's *Cryphiops* established in 1852 for a remarkable species with eyes deeply concealed beneath the carapace. This form, from fresh-water streams in Chili, has never been rediscovered and a more complete account of the genus is most desirable. It differs from *Euryrhynchus* in having a three-jointed mandibular palp*: from Dana's figure (1855, Atlas, pl. 39, fig. 4 a) it would appear that the peduncle of the uropod is produced somewhat at the upper postero-lateral angle, although not nearly to the same extent as in *Euryrhynchus*. Dana does not figure an exopod to the external maxilliped. In *Brachycarpus*, for example, the postero-lateral angle of the peduncle of the uropod is also considerably produced and in *Palaemon* it forms a rounded lobe, but I do not know of any genus in which it forms anything resembling the process found in *Euryrhynchus*. It differs from all the other genera of the Palaemoninae in having the rostrum depressed and toothless, and thus somewhat resembles an Alpheid in general appearance. The row of uropodial spines (fig. 14 c) is also most unusual in the Palaemonidae; there is, as a rule, only one movable spine or spinule on the exopod. The genus exhibits other unusual features to be mentioned later (p. 336).

EURYRHYNCHUS WRZESNIOWSKII Miers.

Miers, 1877, p. 662, pl. lxii, fig. 2; Calman, 1907, p. 297.

Material.—No. 550, 30. vii. 33. 13 ♂♂, 10 ♀♀ (the largest ovigerous). No. 552, 31. vii. 33. 14 ♂♂, 16 ♀♀.

Both these lots are from the Manicole Swamp, near Camp 3, Upper Cuyuni, British Guiana.

Also 19. v. 33. 2 ♀♀ from Forest Pool near Penal Settlement, Mazaruni, British Guiana.

Habitat.—Dr. Carter has given me the following data:—‘The swamp in which *Euryrhynchus* was found was a peculiar one. It occupied a hollow, without outlet, on rather high ground in the forest, and therefore in the full shade of the canopy. The bottom of the swamp was covered by a very thick layer of dead leaves—the only place in Guiana where I found decaying leaves in a thick layer. The water was very yellow and highly deoxygenated. There was much H_2S among the leaves. The plankton was slight except for *Euryrhynchus*, which was present in considerable numbers in the water and among the upper layer of the leaves, and small fishes (*Rivulus urophthalmus* and *Pyrrhulina filamentosa*) swimming chiefly near the surface of the water.’

Description of male.—Rostrum short, depressed, acutely triangular with 3–4 long slender setae on each side (fig. 13 a & b); as a rule, it is shorter than,

* In his key to the genera of the subfamily Palaemoninae Kemp (1925, pp. 284–5) has inadvertently placed the genus *Cryphiops* Dana in Section II, with mandibular palp absent.

but may be equal to, the eyes; it does not project beyond the pterygostomial angle of the carapace.

Antennal spines acute, shorter than rostrum; no other spines are present on the carapace (fig. 13*a*).

Eye.—Stalk partially concealed under anterior margin of carapace; no definite line of demarcation between stalk and cornea, the latter being of small size with a very irregular margin (fig. 13*b*).

Antennule with outer flagellum completely divided; the shorter ramus is of an unusual type, thicker than either of the long flagella, with a group of

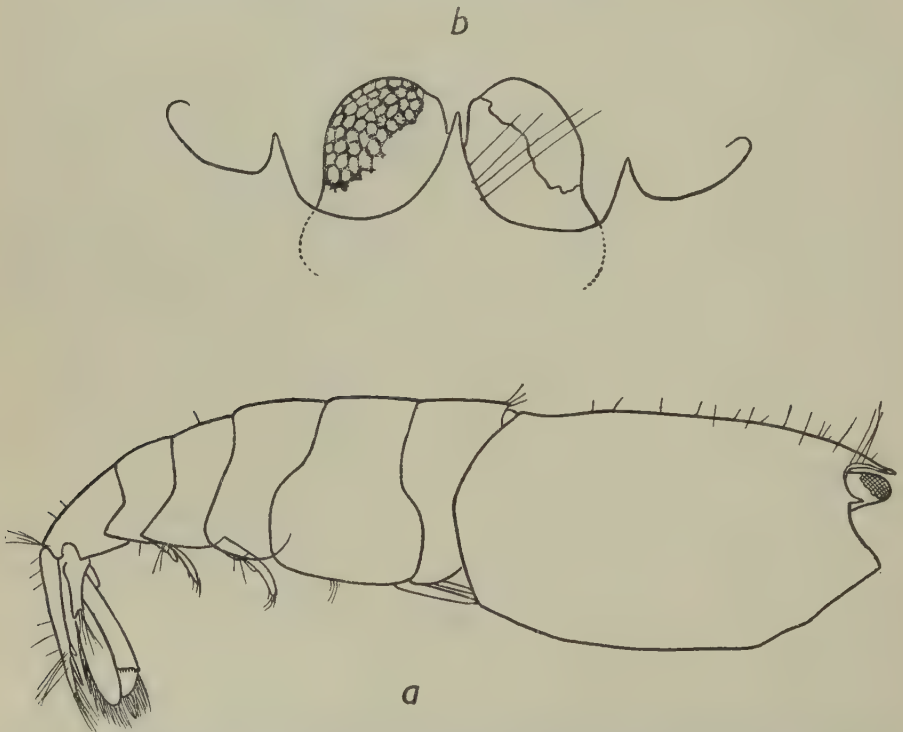


FIG. 13.—*Euryrhynchus wrzesniowskii* Miers, ♂. *a*, lateral view of carapace and abdomen showing the deep anterior abdominal pleura and the small pleopods, $\times 8$; *b*, anterior border of carapace showing rostrum, antennal spines, and eyes, $\times 36$.

special spatulate spines at the blunt apex. In large specimens (up to 18–19 mm. long) it has five, in smaller specimens four or only three, segments (fig. 14*b*). The long flagella are subequal and reach almost to the posterior margin of the carapace when bent backwards. Proximal segment of peduncle rather longer than the sum of second and third segments, with outer distal angle spinose; stylocerite of small size, overlapping the segment; statocyst present (fig. 14*b* & *b*¹).

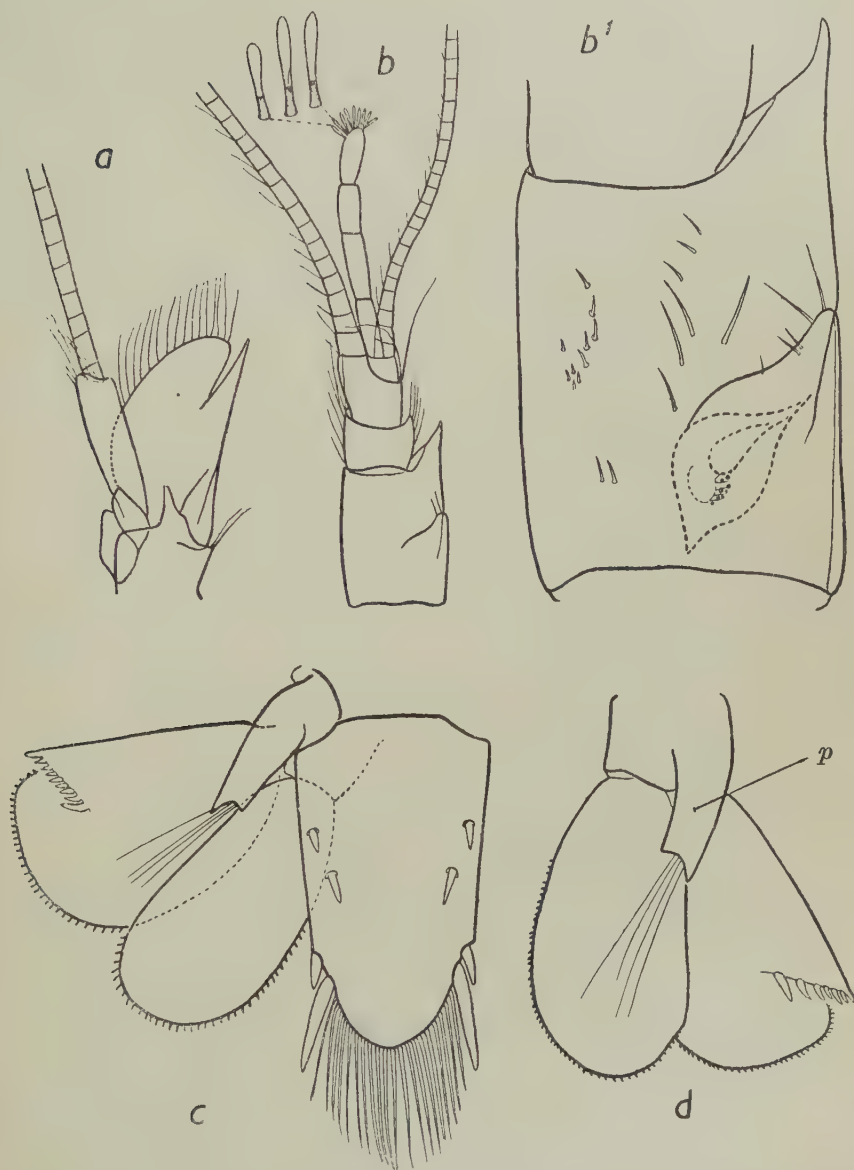


FIG. 14.—*Euryrhynchus wrzesniowski* Miers. *a*, antenna; *b*, antennule with 4-jointed accessory ramus of outer flagellum; *b*¹, basal segment of antennular peduncle further enlarged to show statocyst (after a sketch made by Dr. C. J. Shen); *c*, telson and left uropod drawn from a mounted preparation; *d*, right uropod of another specimen. *a*, *b*, *c*, & *d*, $\times 20$.

Antenna (fig. 14 a).—Scale rather longer than antennular peduncle; flagellum as long as the body

Mouth-parts.—Mandibles without palp, as represented in fig. 15; maxillule as in fig. 17 d; maxilla with endite undivided (fig. 16 c). Exopods of all three maxillipeds well developed; first and third as represented in fig. 16 a & b; an arthrobranch on the second, a small pleurobranch on the third maxilliped.

First peraeopods equal, chelate, and slender, exceeding antennal scale by most of the carpus and the chela; the former somewhat enlarged distally, its greatest width being rather more than one-seventh of the length. Chela over one-half as long as carpus, fingers and palm subequal, distal lower border of palm

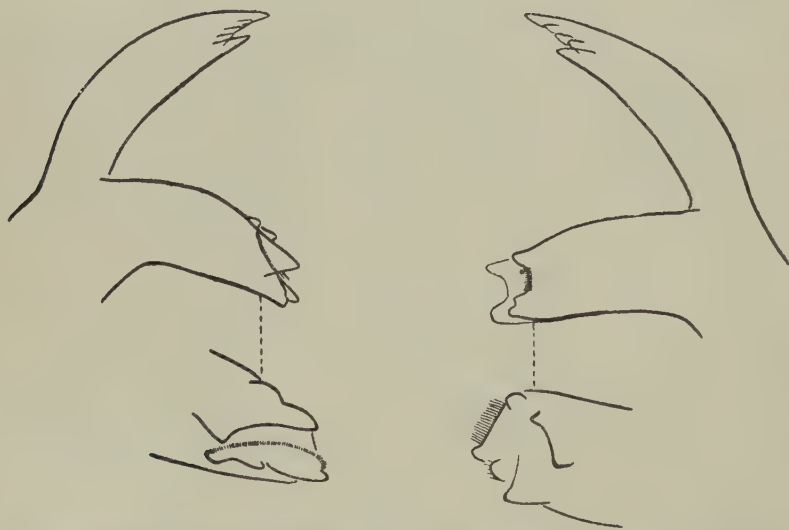


FIG. 15.—*Euryrhynchus wrzesniowski* Miers. Right and left mandibles, $\times 48$ & 60.

and proximal half of fixed finger fringed with setae each of which is plumose distally (fig. 17 a).

Second peraeopods unequal, much larger and more robust than any of the other peraeopods. Merus of larger cheliped rather shorter than carpus, with lower surface finely granulose and slightly hollowed distally, the edges of the groove terminating in short rounded or subacute lobules. Similar but finer granules on carpus and chela, which are rather flattened; the former is nearly as long as the palm and abruptly narrowed at the proximal end. Fingers somewhat longer than palm with 2 or 3 teeth near proximal end of cutting-edge of dactylus and 1 or 2 near base of fixed finger; each of the fingers terminates in a sharp curved tooth. Smaller chela very similar, but without

teeth on the inner margin of each finger. Both chelipeds clothed with rather sparse slender setae.

Peraeopods 3 and 4 of equal length, the third reaching to the end of the

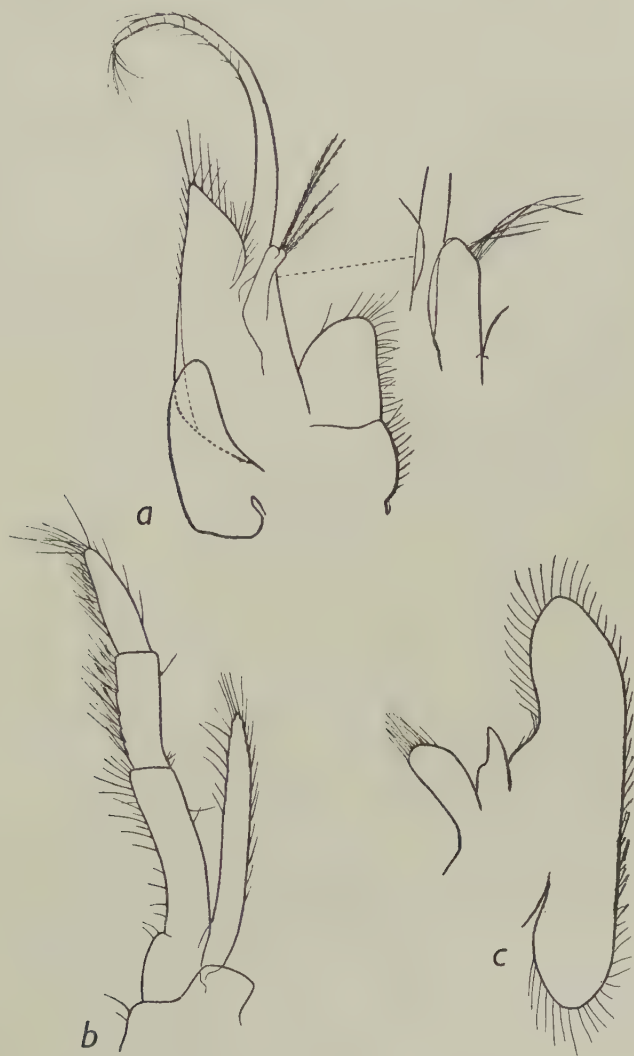


FIG. 16.—*Euryrhynchus wrzesniowski* Miers. *a*, first maxilliped, $\times 27$;
b, third maxilliped, $\times 20$; *c*, maxilla, $\times 35$.

carpus of the smaller second cheliped; propodus armed ventrally with a few spines as in fig. 17 *b*; dactyli biunguiculate.

Fifth pereopod rather longer and more slender than fourth; propodus

with a few small spines on ventral margin and numerous finer spinules arranged in 6-8 short series at distal end as represented in fig. 17c.

The thoracic *sternite* in front of the third pair of peraeopods slopes forwards and downwards, forming a rather prominent ridge immediately behind the larger chelipeds; the apex of this ridge is almost exactly on a level with the distal

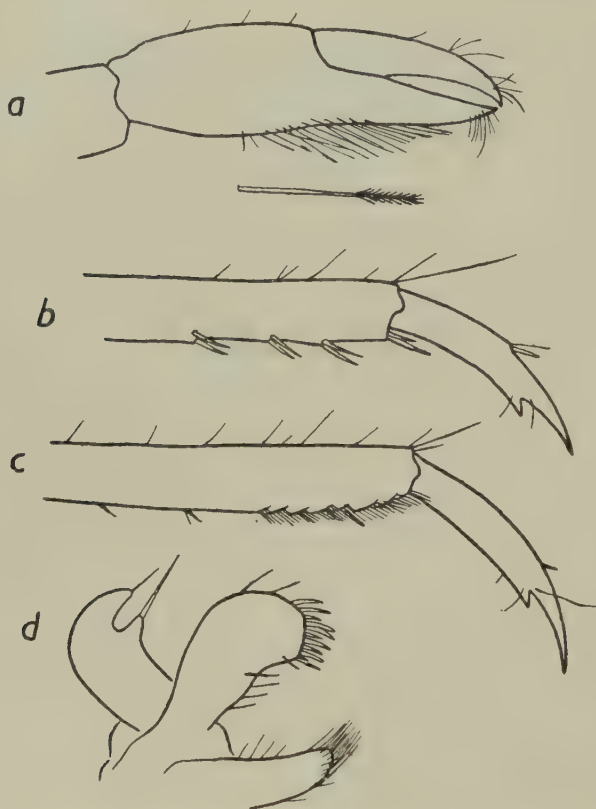


FIG. 17.—*Euryrhynchus wrzesniowski* Miers. *a*, chela of first peraeopod; *b*, distal end of fourth peraeopod; *c*, distal end of fifth peraeopod: all $\times 36$. *d*, maxillule, $\times 60$.

end of the coxopodite of peraeopod 3. A similar though lower ridge is situated posterior to the smaller pair of chelipeds.

Spermatophores.—In most, though not in all, of the larger males there is a conspicuous dark brown structure projecting from between the bases of the closely approximated fifth pair of peraeopods. It varies considerably in shape as well as in size, and is usually forwardly directed, though in some cases it projects backwards or obliquely downwards (fig. 18*b* & *e*). In one rather small specimen there are two separate tubular projections, one from each genital opening (fig. 18*a*). In all the other specimens these two parts have become

firmly cemented together or fused, so that they cannot be separated without damaging the structure. These are doubtless spermatophores of a rather unusual type; the envelope is tough and rather thick, and the central core of each half, in the one removed for examination, was filled with closely packed round bodies, presumably spermatozoa. These spermatophores can be detached very easily; the envelope is probably secreted by the vasa deferentia (see also p. 336).

Abdomen as represented in fig. 13 *a*; the pleura of the first two segments especially are deep and bend inwards towards each other on the ventral surface

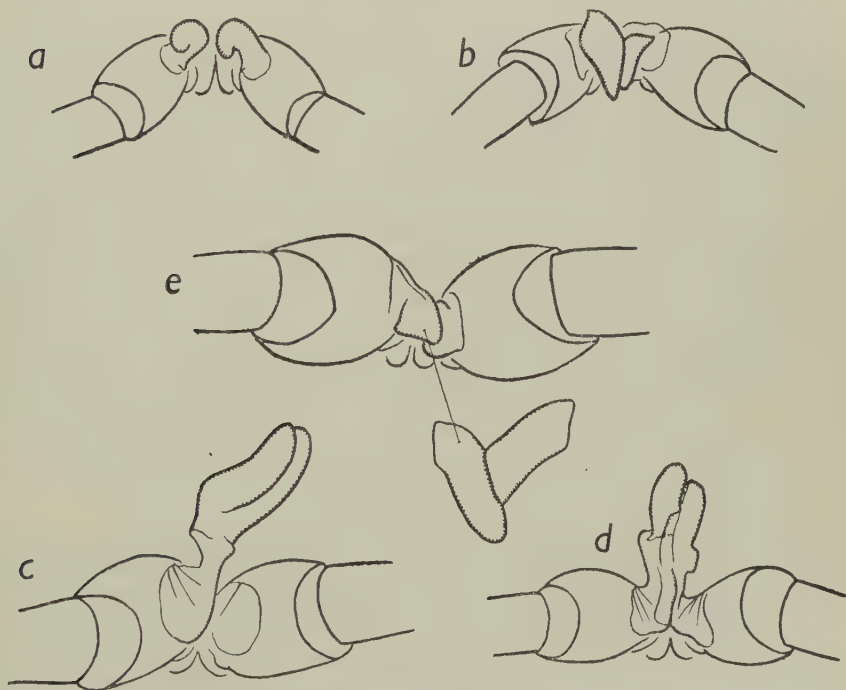


FIG. 18.—*Euryrhynchus wrzesniowski* Miers, ♂. *a-e*, spermatophores projecting from bases of fifth pereopods in specimens measuring respectively 11, 13, 16.5, 14.5, and 17 mm. in length. All $\times 36$.

so as to conceal the first three pairs of pleopods almost entirely in lateral aspect. These pleopods are directed forwards close to the ventral surface of the body, so that only the first and second pairs are visible from the side. The gap left between the second pair of pleura in the largest males is about half the total width of the abdomen.

Pleopods (fig. 19 *a-e*).—These are much reduced in size; the second pair are the longest and they touch, or nearly touch, the posterior margins of the coxopodites of the fifth pereopods. When the abdomen is slightly flexed

they touch the spermatophore that projects from the genital openings. The appendix masculina is absent and the appendix interna is reduced to a small protuberance on the inner margin of the long endopod. Distal to this knob is a series of strong spines; those near the apex are short and curved forwards (fig. 19 *b*). There is another row of spines on the anterior surface of the endopod, almost parallel with those near the inner margin, although they are not shown in the figure. The posterior three pairs of pleopods have the endopod reduced almost to the appendix interna (fig. 19 *c-e*).

Telson as represented in fig. 14 *c*; the rounded apex is produced well beyond the point of insertion of the 'terminal' spines; the usual two pairs of spines occur on the dorsal surface.

Uropod with the dorsal outer angle of the peduncle produced obliquely backwards to form a characteristic long process *p* (fig. 14 *c* & *d*). Exopod with a series of 6-9 spinules; only the bases of the setae are represented in fig. 14 *c* & *d*.

Female at first sight very similar to the male, as in many Caridea; but on closer examination it is evident that there is a well-marked sexual dimorphism, so that even the smallest specimens (*l.*=8 mm.) are easily distinguishable. In the female the pleopods differ markedly from those of the male, and this applies more or less to the whole series, not only to the first two pairs (*cf.* figs. 19 & 20). The third, not the second, pair is longest in the female and the endopod is nearly as long as the slender exopod (fig. 20 *c*). The first two pairs are very similar and, as neither is setose, they are quite unsuited for carrying the ova. The endopod in each tends to overlap the exopod; in the figure of the second pleopod this overlapping is not shown. Immature specimens can be recognised as male or female at once by the differences in the first two pairs of pleopods (fig. 21 *a* & *b*).

As the female approaches maturity the pleura of the first two abdominal somites increase more rapidly than those of the male, so that they soon meet and even overlap somewhat on the mid-ventral line (*l.*=12-13 mm.). These pleura must enlarge enormously during the breeding season, for in the largest and only ovigerous female (*l.* about 14.5 mm.) they form a large brood-pouch for the enormous ova (some 9 in number). The ova are in a very early stage of development. The brood-pouch is formed almost entirely by the thin flap-like first and second pairs of pleura (fig. 21 *c*). The third pair are much smaller and almost close the pouch posteriorly; the last two pairs of pleopods are excluded from the pouch, and they may help to send a slight current of water through it so as to aerate the ova.

Remarks.—I have not re-examined the specimens of *E. burchelli*, but the species seems to differ from *E. wrzesniowski* in several respects. The rostrum is longer; the carpus of the second peraeopod is rather shorter and has an acute subterminal spine on the inner side; the merus also has two acute spiniform teeth at the distal end of its lower surface instead of two rounded lobules. Calman does not figure any backwardly directed extension of the peduncle of the uropod (1907, fig. 8, p. 298). Until more material is available it seems

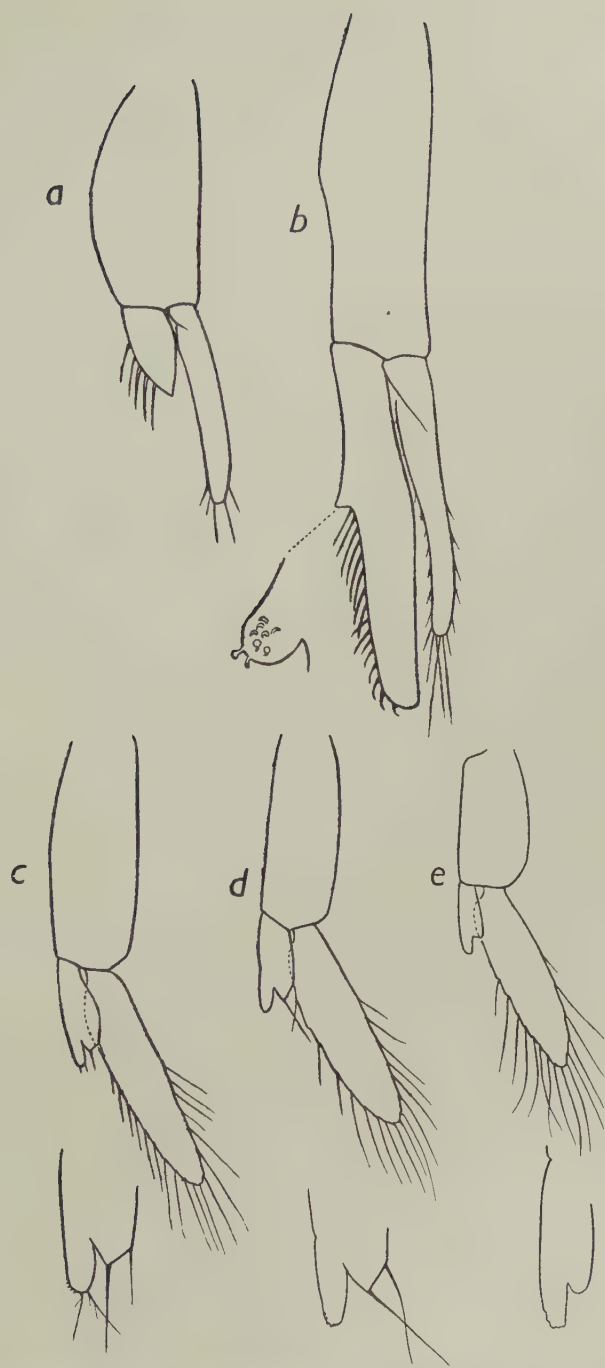


FIG. 19.—*Euryrhynchus wrzesniowski* Miers, ♂. *a-e*, pleopods 1-5 from right side of a specimen 17 mm. long, $\times 36$. The appendix interna further enlarged to show the much reduced retinacula; appendix masculina absent.

advisable to retain the two species, especially as none of the specimens of *E. wrzesniowskii* has a spine on the carpus of the second pereopod.

E. wrzesniowskii exhibits not a few unusual and interesting features:—The stout 3–5-jointed accessory flagellum of the antennule with its terminal group of spatulate spines; the extraordinary sexual dimorphism of the reduced pleopods; the enlargement of the anterior abdominal pleura in both sexes, but especially in the female; the long backwardly directed extension of the outer angle of the peduncle, and the row of spinules on the exopod of the uropod.

With regard to the brood-pouch, although it is rare in Macrura, it is not unique. Balss (1914, 1915) has described a very modified Pontoniid *Paratypton siebenrockii* with enormously enlarged abdominal pleura forming 'ein völlig geschlossener Raum zur Aufbewahrung der Eier'. In *Paratypton* the pleopods are not much reduced in size, although the setae are very short and the endopods and exopods are broad and leaf-like. It is of interest to find a well-developed brood-pouch in two Caridea of such widely different habits and from very different habitats. *Paratypton* is a marine form from the Red Sea; Balss states that it is 'in Korallenstöcken lebend, in denen er Gallen bildet'*. *Euryrhynchus* is a free-living fresh-water form. It is not unusual in Caridea for the anterior abdominal pleura to be considerably enlarged in the female so as to protect the egg-mass laterally, as e.g. in *Leptochela* where the pleopods are normal and the ova of small size. In *Palaemonetes carteri* the pleura enclose the rather large ova laterally and to some extent ventrally as well, but here again the pleopods are normal and the ova are attached to their setae (p. 326). In *Euryrhynchus* the pleura completely enclose the ova; from the large size of the latter it is probable that the larvae emerge at an unusually advanced stage of development.

The presence of a conspicuous spermatophoral mass in so many of the males is also an unusual feature. I have never seen similar spermatophores in any other genus of the Caridea, and very little seems to have been published on sperm transference in that tribe. None of the female specimens of *Euryrhynchus* shows any trace of the spermatophores either adhering to the thoracic sternite or protruding from a spermatheca. Nor have I been able to detect the presence of a special thelycum; the female sternite between the bases of pereopods 2–5 is very similar to that of the male, but, if sections were cut, some sort of receptaculum seminis might be found. Andrews (1911, p. 419) states that in Crustacea it is usual for the sperm to emerge from the male in masses, 'enveloped in more or less secretion from the deferent ducts. . . . These spermatophores are received by the females chiefly in three ways—either the spermatophores are fastened merely upon the outside of the shell† or they are introduced into the oviducts or they are placed within some spermatheca or receptacle not used for any other purpose' (e.g. Penaeids, *Cambarus*,

* Kükenthal and Krumbach, 'Handbuch der Zoologie', iii, 1, p. 968 (1927).

† *Astacus*, also *Panulirus* and *Paribacus* (Andrews, 1912).

Homarus). Of *Peneus* Andrews states further 'the way the secreted mass (of spermatozoa) fills the cavity of the thelycum indicates that it is run in when soft and subsequently "sets" more or less' (1911, p. 424). In *Cambarus*,

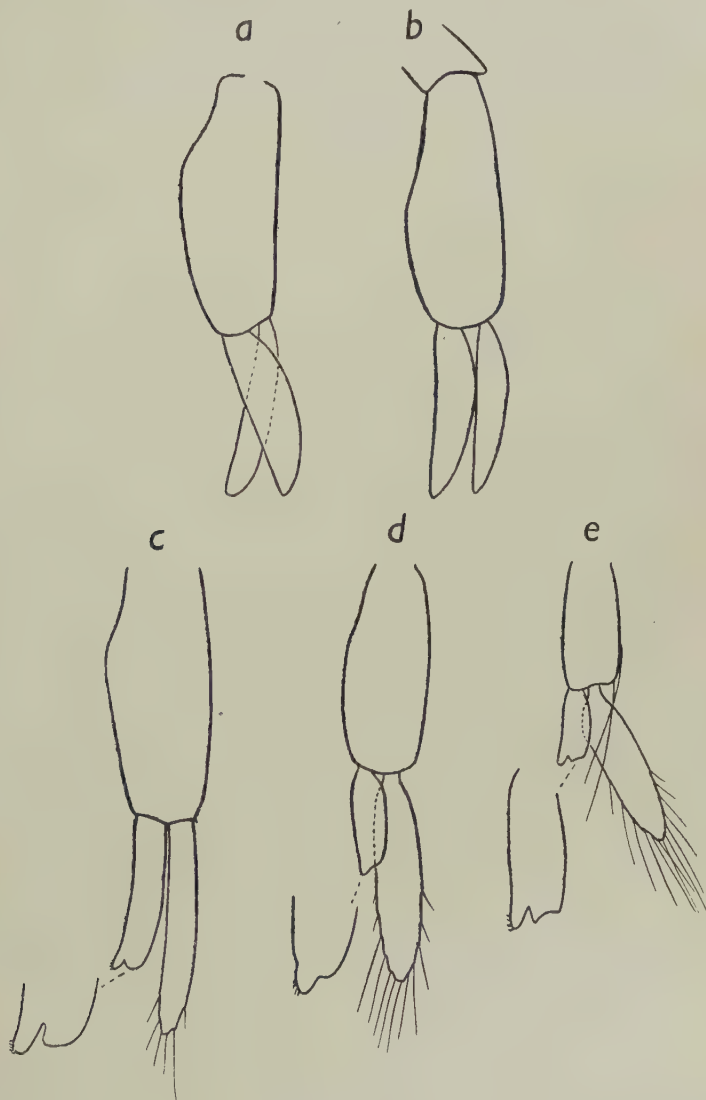


FIG. 20.—*Euryrhynchus wrzesniowskii* Miers, ♀. a-e, pleopods 1-5 from right side of a specimen 13.5 mm. long. $\times 36$.

which Andrews has studied in considerable detail (1910, 1911 a, and other papers), the spermatozoa are also run into the receptaculum seminis. In *Euphausia* the spermatozoa are enclosed in flask-shaped spermatophores

which are formed within the widened terminal parts of the vasa deferentia. This pair of spermatophores is frequently found attached to, and projecting from, the receptaculum seminis of the female. It is unusual, I understand, to find the spermatophores projecting any distance from the male genital pores; sometimes the tip protrudes and then a slight pressure is sufficient to cause it to emerge altogether. Andrews (1911, p. 432, fig. 14) shows a large, retort-shaped, dark spermatophore, over 2 mm. in length, projecting from the

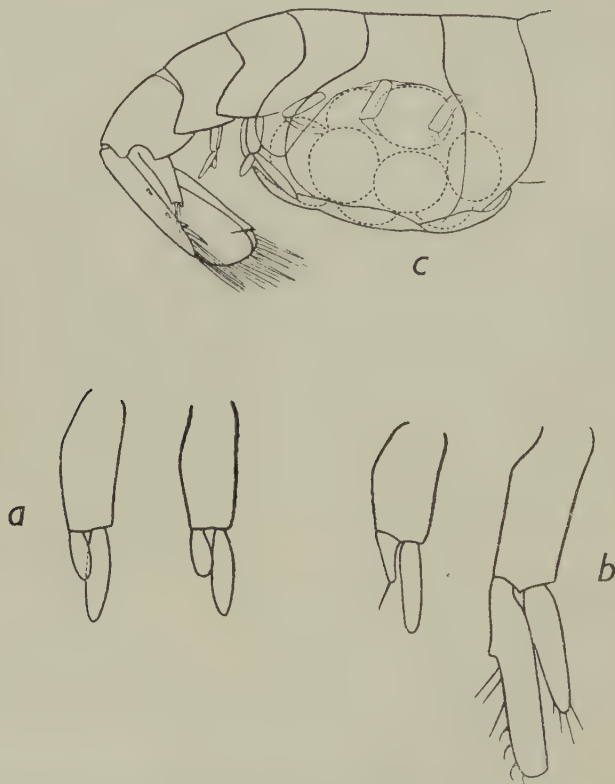


FIG. 21.—*Euryrhynchus wrzesniowski* Miers. *a*, pleopods 1 and 2 of a small female, l.=8 mm.; *b*, pleopods 1 and 2 of a small male, l.=8 mm.; *c*, abdomen of ovigerous female to show brood-pouch. *a* & *b*, $\times 48$; *c*, $\times 8$.

male genital aperture of *Polycheles sculptus*. He was able to trace this dark cylinder up the entire length of the vas deferens to the testis where it ended abruptly, and adds 'apparently the sperm mass is long enough to supply spermatophores to two or three females'. He also figures a pair of such spermatophores fused together and fastened to the sternum of the female between the last pair of peraeopods (1911, p. 429, fig. 11).

In *Euryrhynchus* the spermatophores usually fuse together as they are

formed by the male ; it would be interesting to know how long they are thus carried by the male prior to copulation and the manner in which they are transferred to the female.

The cornea of the eye, though of small size, is well pigmented and faceted ; its irregular edge is most unusual. *Euryrhynchus* had hitherto been found only in wells and may be in process of adapting itself to a subterranean habitat. In this connection it is of interest to mention that Kemp (1924, pl. iii. figs. 1 & 2) found a cave-dwelling *Palaemon* with the cornea of the eye greatly reduced in size, yet with all the normal visual elements present, apparently without the least sign of degeneration. It is difficult to understand of what use such eyes could possibly be to *Palaemon cavernicola*.

Subfamily PONTONIINAE Kingsley.

Genus ANCHISTIOIDES Paulson.

Kemp, 1925, p. 338 (synonymy and earlier references).

In June 1934 Mr. F. A. Brown, Jr., collected thirty-six specimens of a prawn that seemed to be new to the Bermudan fauna and some time later Dr. J. F. G. Wheeler, Director of the Biological Station, Bermuda, brought a number of these specimens for determination to the British Museum. Dr. Kemp immediately recognised the material as belonging to the rare genus *Anchistioides* Paulson, and, on looking further into the matter, I found that the species did not agree with any of those described from the Indo-Pacific region. Dr. Wheeler, in a letter to Dr. Kemp, has since brought to our attention a paper by Schmitt (1924) in which a very similar form had been described as *Periclimenes antiquensis*. The specimens from Bermuda proved, without doubt, to be identical with this species, which must be renamed *Anchistioides antiquensis* (Schmitt).

The thirty-six specimens collected by Mr. Brown were obtained at night (9-11 p.m.), using an electric light to attract them, and more recently Dr. R. Gurney by the same method has obtained more material at Bermuda which he has kindly allowed me to examine.

In the following pages the systematic position of the genus, about which there has been considerable difference of opinion, is discussed.

AFFINITES AND SYSTEMATIC POSITION OF THE GENUS.

At first Borradaile (1900) regarded the genus *Amphipalaemon* Nobili (= *Palaemonopsis* Borradaile) as belonging to the family Palaemonidae, as also did Nobili (1906 a) ; Balss in 1921 also referred it, doubtfully, to the same family. Borradaile (1915, p. 205 ; 1917 a, p. 405) later established a new family Anchistioididae for the reception of the genera *Anchistioides* Paulson and *Amphipalaemon*. This family he regarded as intermediate between the

Crangonoida and the Palaemonoida and placed it in the former. Balss, in the recent 'Handbuch der Zoologie', Kükenthal and Krumbach, Bd. 3, p. 1003 (1926-27), has adopted Borradaile's classification.

In 1925 Kemp (p. 338) pointed out that *Amphipalaemon* is a synonym of *Anchistioides*, but made no comment on the systematic position of the genus,

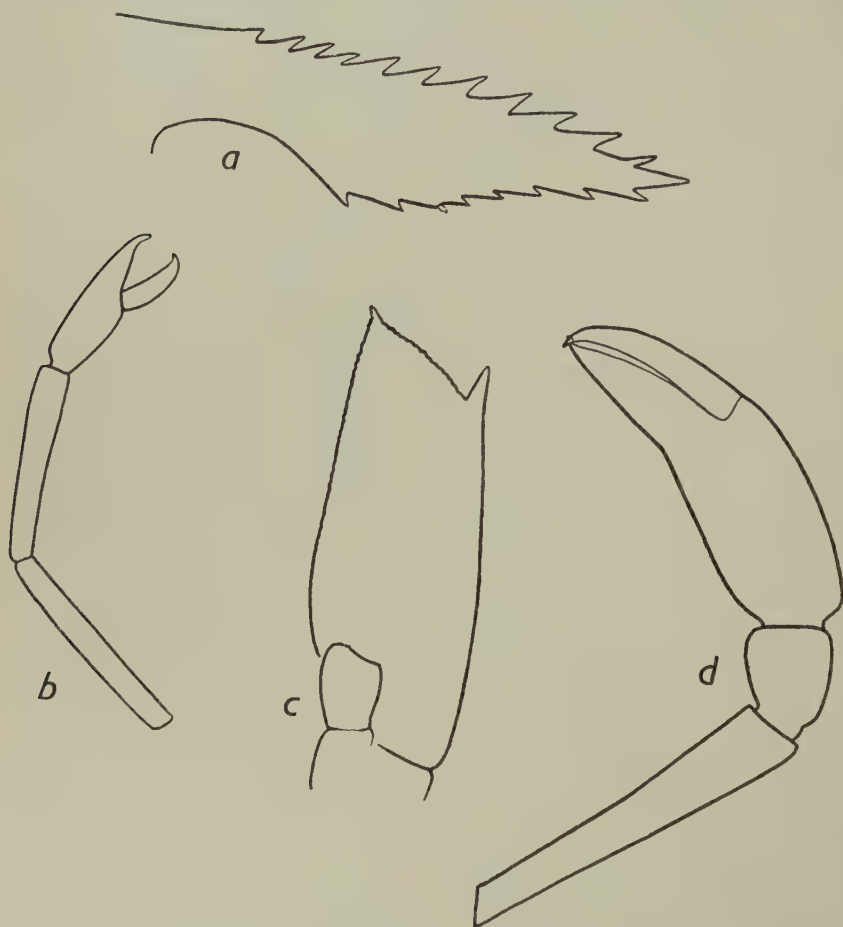


FIG. 22.—*Anchistioides compressus* Paulson. *a*, rostrum; *b*, first peraeopod; *c*, antennal scale; *d*, second peraeopod. All $\times 27$.

leaving it in the family Anchistioididae. I have had occasion to re-examine specimens of all the known species, *A. seurati* Nobili excepted*, and am of opinion that the genus should undoubtedly be placed in the family Palaemonidae. Almost the only Crangonid character would appear to be the

* Type not in Paris Museum.

complete suppression of both proximal and distal endites in the uaxilla. Borradaile (1917, p. 337) found that, in the subfamily Pontiinae, the distal bilobed endite of the maxilla tends to become simple* and says that 'from the frequent occurrence of reduction in the lobes of this limb in Carides, it would seem that they are not of great physiological importance'. It is reasonable to suppose that this tendency to reduction might be carried a step further within the subfamily Pontiinae itself, and this is indeed the case in *Paratypton* Balss (1915, p. 30, fig. 22).



FIG. 23.—Antennal scale of : *a*, *Anchistioides willeyi* Borradaile, holotype ; *b*, *Anchistioides gardineri* Borradaile, holotype ; *c*, *Anchistioides cooperi* Borradaile, holotype ; *d*, *Anchistioides australiensis* Balss, cotype. *a* & *b*, $\times 16$; *c* & *d*, $\times 20$.

The palaemonid characters are certainly more convincing, e.g. the presence of an incisor process to the mandible and of an accessory branch or ramus at the base of the outer antennular flagellum (fig. 26*b*). There is also, as in all Pontiinae, perhaps in all Palaemonidae, a well-developed statocyst. The stylocerite, although much reduced, is closely applied to the basal segment

* In *Typhlocaris galilea* Calman the distal endite is also a simple and very narrow lobe (1909, pl. 19, fig. 7).

of the peduncle, which it overlaps. In most of the Palaemonidae that I have examined the stylocerite ends in a spine and is larger, but always overlaps the basal segment. In *Crangon*, which is one of the Crangonoida with a statocyst*, the stylocerite is a large lanceolate structure lateral to the basal segment, i.e. with no overlapping (see Shen, 1934, p. 540, pl. viii. fig. 51). Until a more extensive comparative study of the stylocerite and statocyst has been made, too much importance cannot be attached to them, but in this instance they would seem to point to affinities with the Palaemonidae rather than with the Crangonoida.

The gill-formula differs from that of the subfamily Palaemoninae and agrees with that of the Pontoniinae and Typhlocaridinae (see key in Borradaile,

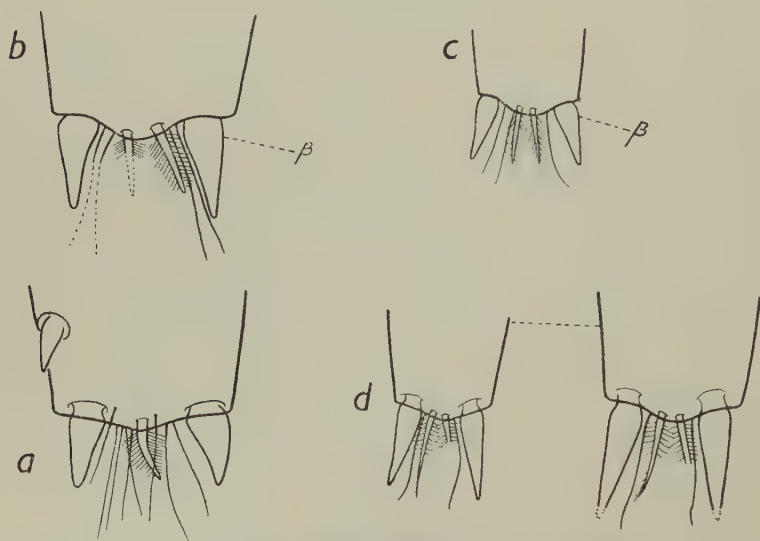


FIG. 24.—End of telson of: *a*, *Anchistioides willeyi* Borradaile, holotype; *b*, *Anchistioides gardineri* Borradaile, holotype; *c*, *Anchistioides cooperi* Borradaile, holotype; *d*, *Anchistioides australiensis* Balss, cotypes. *a* & *b*, $\times 48$; *c* & *d*, $\times 60$.

1915, p. 206; 1917, p. 326; modified below, p. 343). *Anchistioides* differs from the Typhlocaridinae in having the outer flagellum of the antennule deeply cleft and in the absence of a suture on the side of the carapace.

According to Borradaile the Pontoniinae invariably possess six spines at the tip of the telson, and his figures (Borradaile, 1917, pls. lii.-lv. fig. *p*) show a pair of short spines at or near the postero-lateral angles, a longer outer and shorter inner pair on the posterior margin. Kemp (1922, p. 113) produced

* The statocyst in *Crangon* is a shallow pit, situated in the middle of the upper surface of the basal segment of the antennular peduncle, the opening being protected by a series of large bristles instead of by a fold of the stylocerite,

some evidence to show that this distinction between Pontoniinae and Palaemoninae is not absolutely constant.

In the genus *Anchistioides* the number and arrangement of the spines at the end of the telson varies somewhat. In *A. antiquensis* (fig. 25*b*, p. 346) the spines (α) at the postero-lateral angles are very minute as a rule, but are rather large in one abnormal specimen (fig. 25*b*¹). The outer pair on the posterior margin (β) are as long as, or longer than, the posterior border; the inner pair, present in most Pontoniids, is absent or replaced by a single median spinule (fig. 25*b*). There are, in addition, two or three setae. In one aberrant specimen there are three spines on one side, only two on the other, but it is probable that the end of the telson had been regenerated (fig. 25*b*¹).

In *A. willeyi*, *A. cooperi*, *A. gardineri*, and *A. australiensis* the postero-lateral pair of spines (α) is absent (fig. 24*a-d*); the outer terminal pair (β) are rather short and stout, and are probably not longer than the posterior margin*. The inner pair is replaced by two finely feathered setae as a rule, by only one in *A. willeyi* (fig. 24*a*). Such slight differences are certainly not sufficiently important to justify the retention of the family Anchistioididae nor to place the genus *Anchistioides* in a separate subfamily; I have placed it, therefore, in the Pontoniinae.

Section II of Borradaile's key (1917, p. 326) to the subfamilies of the Palaemonidae, in which rather too much prominence has been given to the number of spines at the end of the telson, may be somewhat modified as follows:—

- II. Two pairs of spines on the dorsal surface of telson; surface of molar process of mandible bearing some 5–6 large knobs or crests.
- A. A pleurobranch on the third maxilliped. [Outer flagellum of antennule deeply cleft; no suture on side of carapace; usually 4 spines and a varying number of feathered bristles at end of telson.] *Palaemoninae*.
 - B. No pleurobranch on the third maxilliped.
 - 1. Side of carapace traversed by a suture; accessory ramus of outer flagellum of antennule vestigial *Typhlocaridinae*.
 - 2. Sides of carapace not traversed by a suture; base of outer flagellum of antennule thickened and fringed with coarse sensory setae; a cleft† of varying length separates the apex of this thickened region from a long slender flagellum; [usually three pairs of spines at end of telson] *Pontoniinae*.

The position of *Anchistioides* in the key to the genera of the Pontoniinae given by Kemp (1922, p. 120) is in section C, subdivision D' along with *Pontonides* and *Balssia*; all three genera agree in having the 'exopods absent from some or all maxillipeds'. *Anchistioides* differs from both *Pontonides* and *Balssia* in having the endites of the maxilla completely suppressed.

* The apices are broken off in the larger type-specimen of *A. australiensis*.

† Except in the genera *Typton* and *Paratypton*.

Section C, subdivision D' of Kemp's key may be extended as follows to include the genus *Anchistioides* :—

D'. Exopods absent from some or all maxillipeds.

E. Carapace not sculptured; no mid-dorsal tooth on first abdominal somite.

F. Rostrum toothless; no large blunt tubercle on carapace behind the eye; free-living (?) or associated with Gorgonians *Pontonides*.

F'. Rostrum with teeth; a large blunt tubercle on carapace behind the eye; antennal scale usually with a distinct internal angle; telson deeply channelled on upper surface; first pleopod with an appendix interna; endites of maxilla completely suppressed; free-living (?) *Anchistioides*.

E'. Carapace deeply sculptured, with a supraorbital crest on either side armed with teeth; a mid-dorsal tooth on first abdominal somite; rostrum with teeth; associated with red coral *Balssia*.

The following seven species of *Anchistioides* have been described, mostly from one or two specimens * :—

Indo-Pacific Ocean and Red Sea.

- A. compressus* Paulson, 1875, p. 115, Red Sea, 1 ♂ (l.=15 mm.); Kemp, 1925, p. 339, Port Blair, Andaman Is. 2 specimens about 12·5 mm. in length.
A. willeyi Borradaile, 1900, p. 410, Ralun, New Britain, 1 ovig. ♀ (l.=30 mm.).
A. seurati Nobili, 1906 a, p. 259; 1907, p. 364, Tearia, 1 ♂ (l.=12 mm. ?).
A. gardineri Borradaile, 1917 a, p. 407, N. Malé Atoll, 1 ♂ (l.=30 mm.).
A. cooperi Borradaile, 1917 a, p. 407, S. Nilandu Atoll, 1 juv. (l.=15 mm.).
A. australiensis Balss, 1921, p. 11, off Cap Jaubert, 2 ♀♀ (l. of larger=24 mm.).

Atlantic Ocean.

- A. antiquensis* Schmitt, 1924, p. 84. Antigua, 1 ♂ (l.=19 mm.).

Of these I have re-examined one of the specimens of *A. compressus* determined by Kemp and the type-specimens of *A. australiensis*, *A. willeyi*, *A. gardineri*, and *A. cooperi*. Nobili's description of *A. seurati* is very brief; no mention is made of the shape of the antennal scale or of the telson. It agrees with *A. compressus* and differs from all the other species in having the fingers of the second peraeopod shorter than the palm. Nobili states that the fingers of the first peraeopod are a little longer, whereas in *A. compressus* they are rather shorter, than the palm. The type-specimen is not in the Paris Museum, and the figure is not sufficient to settle whether or not it belongs to *A. compressus*.

I find so little difference between the remaining Indo-Pacific species that I have not been able to separate them in the key. It is most probable that they belong to a single species. Certainly the holotypes of *A. willeyi* and *A. gardineri* are the female and the male respectively of one species. *A. cooperi*

* *A. gasti* Balss, 1921 (Mitt. Zool. Stat. Neapel, xxii, p. 523) has been made the type of the genus *Balssia* Kemp.

is represented by a single immature specimen; the very narrow rostrum may well be a juvenile character. *A. australiensis* differs only in some minor points from *T. willeyi*: (1) the rostrum is rather longer, but in *A. gardineri* it also exceeds the antennal scale, reaching as far forward as the setae on the latter; (2) the fingers of the second peraeopod are rather longer in proportion to the palm (1.3 and 1.59:1 as against 1.12 in *A. willeyi*) and the merus is rather more slender; (3) the outer pair of spines on the posterior margin of the telson are rather longer, though not as long as figured by Balss. In the smaller specimen the rostrum is rather less deep than in the larger, so that in this respect it is nearer to *A. cooperi*. *A. australiensis* is probably at most not more than a variety of *A. willeyi* *.

I have made the following key to the species, but, with so few specimens from the Indo-Pacific region to hand, it is not as satisfactory as I could wish, and will require considerable emendation at the hands of future workers:—

Key to the species of Anchistioides.

- I. Fingers of second peraeopod shorter than palm; rostral formula $\frac{10-11}{7-8}$; species probably of small size (under 20 mm.).
 - A. Fingers of first peraeopod rather shorter than palm.
[Antennal scale short and broad, only about three times as long as wide across base of spine, which ends some distance behind the internal angle (fig. 22 c).] ... *A. compressus* Paulson.
 - B. Fingers of first peraeopod rather longer than palm *A. seurati* Nobili †.
- II. Fingers of second peraeopod longer than palm; species probably exceed 20 mm. when adult (24–30 mm.).
[Antennal scale long and much narrowed distally, at least seven times as long as wide across base of spine, which ends on a level with, or considerably in advance of, the internal angle (fig. 23 a–d).]
 - A. Telson long, slender, and much narrowed towards the apex, so that the length is 15–18 times the distal width; a pair of minute spines at the postero-lateral angles (fig. 25 b, α); rostral formula $\frac{8-10}{5-8}$ *A. antiquensis* Schmitt.
 - B. Telson long, but much less narrowed towards the apex, so that the length is 8–10 times the distal width; no spines at postero-lateral angles; 1–2 feathered setae internal to outer pair of terminal spines β (fig. 24); rostral formula $\frac{6-8}{3-4}$ *A. willeyi* Borradaile, *A. gardineri* Borradaile, *A. cooperi* Borradaile, *A. australiensis* Balss. These are probably co-specific.

* The difference in length of dactylus in *A. australiensis* and *A. willeyi* referred to by Balss (1921, p. 13) does not appear to be valid. The peraeopods are now for the most part detached from the types, but, in the case of peraeopod 3, ratio of dactylus to propodus appears to vary with size and therefore with age. In *A. cooperi* the ratio is 1:3.7; in *A. gardineri* 1:5.6, in *A. willeyi* 1:5.4; in the smaller cotype of *A. australiensis* (l. approx. 17 mm.) it is 1:3.1 and in a detached peraeopod from the larger specimen 1:4.

† Antennal scale not described; from the figure it would appear to be broad with rounded apex, but this may not be accurate (Nobili, 1907, pl. i, fig. 3).

ANCHISTIODES ANTIGUENSIS (Schmitt)

Perichlimes *antiguensis* Schmitt, 1924, p. 84, pls. iii & iv (*P. barbadensis* in error on plates).

Material.—(a) 9. vi. 34. 5 ♂♂, 1 ovigerous ♀ in 10 per cent. formalin. 9. vi. 34. 5 ♂♂, 1 ovigerous ♀, in 70 per cent. alcohol (the ova are in a rather advanced stage of development). Collected by F. A. Brown, Jr. and presented by Dr. J. G. F. Wheeler.

(b) 16. vii. 34. 1 ♂. Collected and presented by Dr. J. G. F. Wheeler.

(c) Feb.—Mar. 1935. 6 ♂♂, 10 ♀♀. Collected and presented by Dr. R. Gurney.

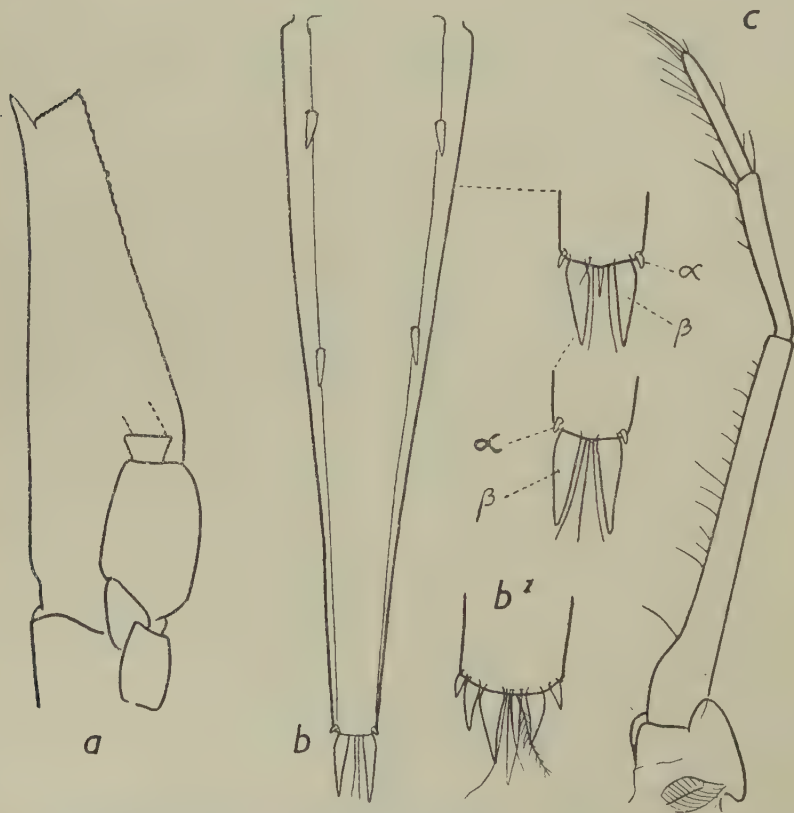


FIG. 25.—*Anchistioides antiguensis* (Schmitt). *a*, antennal scale, $\times 16$; *b*, telson, $\times 27$, and end of telson of two other specimens, $\times 48$; *b¹*, end of telson, rather abnormal; *c*, external maxilliped, $\times 27$; α , spinule at postero-lateral angle; β , outer spine on posterior margin.

Locality.—St. George's West, Bermuda. Previously recorded from Antigua.

Remarks.—These specimens agree closely with Schmitt's description of the male holotype from Antigua. The rostral formula is $\frac{8-10}{5-8}$, usually $\frac{8 \text{ or } 9}{6}$.

The telson is long and much more slender in the distal half than that of any other species (the telson of *A. seurati* Nobili, however, has not been described). There are, in addition to the two pairs of spines (α and β) at the end of the telson, two or three long bristles (fig. 25 *b* shows three slight variations). In the specimen captured on 16th July the end of the telson is rather abnormal (fig. 25 *b*¹) with three spines on the left, two on the right side (see also p. 343).

In the specimen dissected, the epipod of the first maxilliped is a large triangular lobe as represented in fig. 27 *c*. The external maxilliped is slender, without the exopod (fig. 25 *c*); in Schmitt's figure there are two sutures in the antepenultimate segment, but these have probably been inserted by mistake (1924, pl. iv, fig. 7).

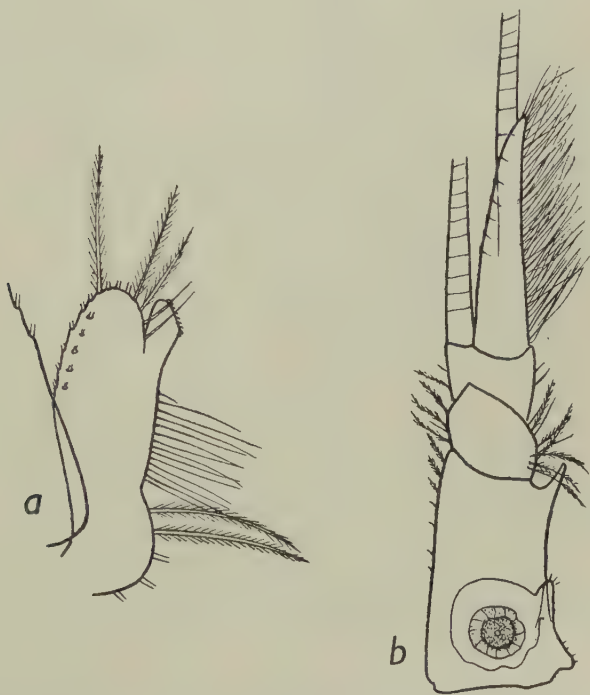


FIG. 26.—*Anchistioides antiquensis* (Schmitt). *a*, endopod of first pleopod of female, $\times 48$; *b*, antennule, $\times 20$.

The spine on the antennal scale terminates slightly in advance of, or on a level with, the internal angle (fig. 25 *a*). The statocyst contains what appears to be an enormous statolith, probably a concretion laid down by the animal itself; the stylocerite is much reduced, with rounded apex, and overlaps the basal segment of the antennular peduncle (fig. 26 *b*).

Anchistioides resembles *Urocaridella* in having an appendix interna on the endopod of the first pleopod in both sexes (figs. 26 *a* & 27 *a*). The males and females are very much alike, and yet those captured in June were probably

easily distinguishable in life. At any rate, in the formalin specimens, which are still quite translucent, the vasa deferentia of the males are conspicuous, wide, uncoiled tubes showing clearly through the sides of the carapace. They are chalky white in colour and quite obvious even to the unaided eye. Specimens



FIG. 27.—*Anchistioides antiquensis* (Schmitt). *a*, endopod of first pleopod of male, $\times 48$; *b*, endopod of second pleopod of male, $\times 48$; *c*, first maxilliped, $\times 27$; *d*, mandible, $\times 27$.

preserved in spirit are, of course, too opaque for the vasa deferentia to be visible, but the genital openings are very distinct. In February and March the animals were not breeding, and those captured were rather smaller. In the non-breeding phase the presence or absence of the *appendix masculina* on the endopod of the second pleopod (fig. 27 *b*) distinguishes the sexes.

This species would appear to be rather common at Bermuda, and it is to be hoped that a detailed study of its habits and its development will be undertaken in the near future. It would be interesting to know where the animals live when not swarming at the surface; also whether they swarm sporadically or with any well-marked periodicity.

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Scientific results of the Cambridge Expedition to the East African Lakes, 1930-1.—No. 15. The fish of Lake Rudolf and Lake Baringo. By E. B. WORTHINGTON, M.A., Ph.D., F.L.S., and C. K. RICARDO, Zoological Laboratory, Cambridge.

(With 2 Text-figures)

[Read 24 October 1935]

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INTRODUCTION.

Each of the great African lakes has a fauna which in many respects is peculiar to itself. Dr. W. A. Cunningham (1920) summarized in a valuable series of lists

the knowledge on the subject as it then existed, but now we know a good deal more; the lists have been expanded, and something is known of the mode of life of the individual species and of their relation to the lakes' ecology. Meanwhile, the economic aspect of the fisheries has come into some prominence, and it is now recognized that fish can provide a most important constituent of diet for African natives. The few studies on native nutrition so far made in the continent show clearly that tribes, almost without exception, suffer from a diet so unbalanced that it is directly or indirectly responsible for many of the major diseases. In general, tribes which till the land suffer from lack of protein, while nomadic and fishing tribes, who usually have sufficient protein, lack those constituents that are supplied by vegetable food. Practically all natives suffer from a deficiency of certain minerals, such as lime, iron and iodine, and several nutritional experts have pointed out that these could be made good by the addition of small quantities of fish to the diet. At industrial and mining centres, where native labour is employed on a large scale, the value of fish is fully recognized. This is the case particularly with the gold mines of the Belgian Congo, which lie within easy reach of the great lakes. Effort is made to obtain fish supplies locally, but the lakes are not yet sufficiently developed to produce enough. It is significant that during the past year or so a trade in dried fish from the Sudan coast of the Red Sea was started to supply native labourers of the Kilomoto gold mines situated to the south-west of Lake Albert. It was a commercial proposition to transport sea-fish half across Africa by rail and road!

There can be little doubt that in years to come the fish resources of the lakes will be used to their maximum; at present they are most decidedly not, but development is taking place all the time. Apart from the numerous lacustrine tribes who obtain their existence from fishing, economic fisheries under European guidance have made some inroads. In the northern group of lakes the 'ngege' (*Tilapia*) fishery of the Victoria Nyanza is still flourishing after passing through many vicissitudes. A fishery on the Belgian Congo shore of Lake Albert has been in progress for ten years, and a British fishery has recently started on that lake, centred at Butiaba. A flourishing Belgian fishery at the south end of Lake Edward was closed two years ago for political reasons, but a British fishery is probably to be inaugurated there. Lake Rudolf is too far from civilization to suffer large-scale economic development in the immediate future, but already, since the Cambridge Expedition of 1930-1, the Kenya Government have taken steps to improve and enlarge the primitive Turkana fishery on the east shore. This is important because the people live in such an inhospitable desert region adjoining the lake that subsistence from the land is quite insufficient for their needs.

In all such development it is of the greatest importance that fisheries should be started on the right lines, based on an understanding of the ecology, and the first stage clearly is to put on record what is known of the fish themselves, their distribution, feeding and breeding habits. This paper forms one of a series

attempting to serve this purpose, and, since the other contributions are somewhat scattered, their references are given in the following list :—

Northern group of lakes* :

Lake Victoria.—‘The Victoria Nyanza and its fisheries’, by Michael Graham, Crown Agents, 1929.

Lake Albert.—‘A report on the Fishing Survey of Lakes Albert and Kioga’, by E. B. Worthington, Appendix 3, Crown Agents, 1929.

Lake Kioga.—*Ibid.*, Appendix 4.

Lakes Edward and George.—‘A report on the fisheries of Uganda . . .’, by E. B. Worthington, Crown Agents, 1932.

Small Uganda lakes.—*Ibid.*, Parts II, III, IV.

Southern group of lakes :

Lake Nyasa.—‘The fishes of Lake Nyasa other than Cichlidae’, by E. B. Worthington, *Proc. Zool. Soc.* 1933, p. 285.

‘A synopsis of the Cichlid fishes of Lake Nyasa,’ by E. Trewavas, *Ann. & Mag. Nat. Hist.* vol. xvi, 1935, p. 65.

Lake Bangweulu.—‘The fishes of Lake Bangweulu other than Cichlidae’, by E. B. Worthington, *Annals & Mag. Nat. Hist.*, vol. xii, 1933, p. 34.

Lake Tanganyika.—Work in progress by Miss Trewavas and present authors.

The papers mentioned on the northern group of lakes are based on actual field observations in addition to collections deposited at the British Museum (Nat. Hist.). Those on the southern group are based on collections made by the late Dr. C. Christy and by Captain C. R. S. Pitman, and information on the size, relative abundance, and food of fish is inadequate—indeed, the lakes are still awaiting proper ecological study.

The data which are summarized in the present paper were collected during routine fishing operations during the Cambridge Expedition, by E. B. Worthington, with the assistance of Mrs. Worthington and L. C. Beadle. The subsequent laboratory work and the preparation of results has been mainly in the hands of Miss Ricardo, who receives a grant from the Conference of East African Governors for research in completing the scientific results of the expedition. All the important fish were caught in large numbers by such gear as set nets, of which half a mile or so of netting was generally set at a time, seines, long lines, trawls, and plankton nets. The heavy seas, so characteristic of Lake Rudolf, were a constant trouble in fishing operations, and crocodiles did great damage to the nets which they entered to feed on the fish.

Matters of purely systematic interest, such as the description of new species, have been recorded in previous contributions to this series of scientific results

* Papers which are purely systematic are not included in this group.

by Trewavas (1933) and Worthington (1932 *b*). In this paper, therefore, systematics are omitted, except where they have important bearings on other aspects.

An isolated lake such as Lake Rudolf can be studied in two rather different ways. Firstly, its fauna and flora as a whole can be compared with those of other waters in order to make out their origin and relationships. Then, with the aid of geological knowledge, reconstructions can be made of changes in land configuration and oscillations of lake level, which have influenced the biological evolution that has taken place since isolation. Secondly, the lake may be considered as an entity in itself, and the individual species which go to make its flora and fauna may be considered in relation to each other and to the several environmental factors such as depth, shore-line, temperature and chemistry. These two aspects are considered respectively under the headings of 'Affinities of the fauna' and 'Ecology'.

During field-work the examination of fish caught was treated as part of the daily routine. First, length was measured in centimetres with a measuring board. In some cases weights of either individual large fish or numbers of small fish were measured with a reliable spring balance. Next the belly was slit, the stomach opened, and its contents examined: in the case of microphagous species the stomach contents were preserved. Finally, the state of gonad development was noted. As a general rule, one worker performed the operations while another recorded the data in the log-book. These field-notes on size, food, breeding, &c., have been sorted and analysed for each species separately, and are presented in the latter part of this paper, where the species are treated in systematic order.

So that the account may be comprehensive and of value as a basis for subsequent work, all fish so far recorded from the lakes are given. The lists therefore include some species which were not taken by the Cambridge Expedition.

LAKE RUDOLF.

History of investigations.

Lake Rudolf was discovered in 1888 by Count Samuel Teleki and Lt. (now Admiral) Ludwig von Höhnelt, and the account of the expedition by von Höhnelt (1894) contains abundant information about the lake. It is worth noting that the English translation omits much of the data contained in the original German. The discoverers made collections of some fossils and land fauna from the Rudolf region, but the first fish were collected in 1895 by Dr. Donaldson Smith, who obtained three species of fish from the lake in that year, and on a second expedition in 1900 brought home one or two more from the Omo River at the north end of the lake. In 1908 Messrs. Zaphiro and McMillan collected on a large scale in Abyssinia; they visited the north end of Lake Rudolf and brought home six more species to the British Museum.

Between then and 1930 one or two other collectors visited the lake, so that by the time of the Cambridge Expedition eighteen species of fish were known

to occur there. During 1930-1 this expedition found seventeen more kinds, and subjected parts of the lake to intensive ecological study for the first time. It is now possible, therefore, to present a picture of the fish fauna, not only as a list of species, but with information concerning their relative abundance, sizes, habitats and relations to each other.

In 1932-3 Dr. P. A. Chappuis of the University of Cluj, Roumania, accompanied Dr. C. Arambourg's palaeontological expedition to the fossil beds near the Omo River (Mission Scientifique de l'Omo), and made a small collection of fish from the northern part of the lake and the Omo River. These have been studied by Dr. Pellegrin (1935) at the Paris Museum, and include one new species and two others which were not previously recorded from the lake. This now brings the number of fish in Lake Rudolf to thirty-eight species or subspecies.

Physical conditions.

The geography of Lake Rudolf has been described by E. B. Worthington (1932c), and the water chemistry, temperature, &c., have been discussed by Beadle (1932), but for convenience a few outstanding characteristics which have direct bearing on the fish are mentioned here.

Lake Rudolf is the most northern of the lakes lying in the main trough of the Eastern Rift Valley. It is long and comparatively narrow, 180 miles by 15 to 35 miles, and lies mainly in Kenya Colony, with the north end projecting into Abyssinia and the Sudan. The lake lies on the eastern side of the Rift Valley, so that the east shore abuts for much of its length against the rift escarpment, giving a steep, sometimes rocky type of shore. To the west there is a strip, some 50 miles wide, of desert country between the shore and the escarpment, so that sandy beaches are characteristic. There are three volcanic islands in a line down the central axis of the lake with steep and often precipitous sides descending rapidly to deep water.

The lake has no outlet, so that its level is subject to considerable variation. There is only one permanent affluent, the Omo, which drains part of the Abyssinian highlands and enters at the extreme north end. In addition, seepage water is received from a number of rivers which are dry in their lower reaches except for a few days in the year, when heavy rains in the mountains cause surface-water to reach the lake. Of these intermittent rivers the Turkwel, with tributaries from Mt. Elgon and the west escarpment of the Rift Valley, is the most important; it enters the lake about halfway down the west shore.

The climate is very hot and dry. Rainfall seldom amounts to more than 5 inches in the year, and sometimes there is no rain for periods of twelve months at a stretch. At rare intervals however, very heavy rains occur and cause wide-scale flooding. V. E. Fuchs (1935) records that during 1934 heavy rains caused vegetation to spring up all over the Turkana desert, the dry water-courses were flooded, and vast quantities of water entered the lake.

A prominent climatic feature is an intense and constant wind from the south-east which blows up the Rift Valley trough. Consequently the open water is nearly always rough with waves of oceanic dimensions. The heavy

surf on all lee-shores renders the environment unfavourable for most inshore fish, but it has had the effect of producing sand-spits, sometimes many miles in length, which project into the lake from previous irregularities of shore-line. In the shelter of these spits there are wide areas of fairly shallow quiet water, where fish and other life abounds. Ferguson Bay, on the west shore, which was the focus of the expedition's work, was formed in this way, and can be taken as typical of several sheltered bays.

The altitude of water-level is about 1,250 feet above sea-level. It has descended considerably since the discovery of the lake in 1888, and the shore-line has changed accordingly: notably several large bays of shallow water, highly suited to inshore fish life, have almost ceased to exist. Between 1931 and 1934 the level descended further some 4 feet. There is a prominent high-level beach at about 450 feet above the present water-level and a number of smaller beaches which show stages in the progressive desiccation. The effect of these changes on the fish fauna is discussed later.

The greatest depth recorded was 69 metres, a few miles north of Central Island. Towards the south end rather deeper water probably exists, but it is unlikely that much of the lake is deeper than 100 metres. In general, the shores shelve comparatively steeply, but in the bays there are stretches of very shallow water which are left as mud-flats when the water-level descends. Except near the shores the bottom deposit, so far as known, is a uniform soft mud.

The temperature of the open water is fairly constant at about $28^{\circ}\cdot5$ C., rising at the surface to 30° during the day. On account of the winds it appears that the water is frequently mixed right to the bottom; the extreme surface, therefore, is not much warmer than the intermediate layers and no thermocline is developed, so that there is no dead water in the lower layers and oxygen is abundant throughout.

A marked chemical characteristic of the water is the high soda content, mainly in the form of sodium carbonate. The alkaline reserve is as high as 0.02 N., compared with 0.01 in Lake Albert or 0.001 in Lake Victoria; the water has a pronounced taste and effervesces vigorously with acids. Slightly alkaline water derived from volcanic lavas is characteristic of most of East Africa, and the shrinking of Lake Rudolf from a much larger size has caused concentration to the present degree. At the extreme north end near the Omo River mouth, the concentration of salts is less.

Affinities of the fish fauna.

The only satisfactory way of showing the faunistic affinities is in the form of a table, such as that on pp. 362-4. The table shows that, of the 38 species and subspecies present in Lake Rudolf, 11 (7 species and 4 subspecies) are found nowhere else and presumably came into existence in the lake itself. Of the remaining 27, 26 occur in the Nile below the Murchison Falls, the remaining one, namely, *Barbus plagiostomus*, being an Abyssinian fish from the upper

tributaries of the Blue Nile and the Hawash River. This establishes beyond doubt the affinities of the fauna as a whole with that of the main Nile below the Murchison Falls. As additional evidence for this conclusion the four endemic subspecies from Lake Rudolf are clearly derived from typical Nile fish, as pointed out by Worthington (1932 *b*, p. 121).

It has sometimes been suggested that Lake Rudolf has affinities with the lakes of the African Plateau above the Murchison Falls, Lake Victoria and Lake Kioga. Only three of the Lake Rudolf fish, however, occur above the Murchison Falls, and these—namely, *Polypterus bichir*, *Heterotis niloticus*, and *Alestes nurse*—are of such wide distribution in tropical Africa that they are no criterion. There is some reason to suppose connexions with the East African rivers, such as the Hawash, Rovuma, and Eusso Nyiro, in that six of the Lake Rudolf species occur in one or other of them.

There is one peculiarity of the Lake Rudolf fauna which is rather difficult to explain on the assumption of a Nile origin, and that is the lack of any member of the family Mormyridae, except *Gymnarchus niloticus*. Some small species may yet be discovered in the lake, but it is improbable that the common large species, such as the 'Elephant-snout fish' of the genus *Mormyrus*, have been overlooked. Species of *Mormyrus*, which are characteristic of the Nile fauna, occupy an important place in other lakes, feeding on fly larvae in the bottom ooze. Suitable environments in Lake Rudolf were intensively fished without producing a sign of them.

Of the 26 Lake Rudolf species present in the Nile, 19 occur also in West Africa, in the Chad basin, Senegal, Gambia, and Niger Rivers. This stresses the fact, of which there is abundant other evidence, that there must once have been a water connection across the southern part of the Sahara. One of the endemic Cichlid fish from Lake Rudolf, *Pelmatochromis exsul*, is another link in this evidence. As pointed out by Miss Trewavas (1933, p. 309) the genus is known elsewhere only from West Africa—a striking example of discontinuous distribution.

The fish fauna of Lake Rudolf, in common with that of Lake Albert, the whole Nile system below the Murchison and Semliki Falls, and certain West African rivers, is characterized by a large number of genera each represented by very few species. The fauna of Lakes Victoria, Kioga and Edward, which are isolated by the Murchison and Semliki Falls, present a contrast in that comparatively few genera are represented, mostly by a large number of species. This striking difference is attributed to the absence of large predator fish, such as Nile perch (*Lates* spp.) and Tiger-fish (*Hydrocyon* spp.), from the Plateau fauna (e.g. Victoria, Kioga, Edward). Without the controlling influence of such predators, the few genera in the plateau lakes have undergone adaptive radiation into numerous closely related species, each filling an ecological niche. In the other type of fauna such adaptive radiation has been prevented by the large predators: this implies that only those species which fit their environment perfectly are allowed to survive.

If this biological control of evolution by predators is borne in mind, the proportion of endemic forms, which have been evolved in each lake, may be taken as a rough index of the period of isolation which the lake has experienced. In making such comparisons the family Cichlidae is best treated separately from the rest of the fish fauna. In percentage of endemic forms Lake Rudolf, in spite of its complete isolation in a closed drainage basin, takes its place between Lake Albert, which is in no way isolated from the lower parts of the Nile, and Lake Edward, which is cut off from Lake Albert by the Semliki Falls. The series for the northern (Nile) group of lakes is shown below. It will be interesting later to compare these lakes with Nyasa and Tanganyika, but until the revision of their fauna is complete*, comparison is not satisfactory:—

Lake Albert.—Connected to the lower parts of Nile without barriers to fish distribution.

Non-Cichlidae :	2	endemics out of 36 species	=	6	per cent.
Cichlidae :	2	„ „ 7 „	=	29	„

Lake Rudolf.—Isolated in a closed drainage basin.

Non-Cichlidae :	8	endemics out of 29 species	=	28	per cent.
Cichlidae :	3	„ „ 6 „	=	50	„

Lakes Edward and George.—Barred from Lake Albert by Semliki Falls.

Non-Cichlidae :	4	endemics out of 14 species	=	29	per cent.
Cichlidae :	18	„ „ 24 „	=	75	„

Lakes Victoria and Kioga.—Barred from Lake Albert by Murchison Falls.

Non-Cichlidae :	27	endemics out of 47 species	=	57	per cent.
Cichlidae :	58	„ „ 64 „	=	91	„

From the preceding discussion the following conclusions can be stated concerning the Lake Rudolf fish fauna :—

(1) It shows very close affinities with that of Lake Albert and the lower parts of the Nile, but not with that of the plateau lakes Victoria, Edward, &c.

(2) The presence of a few forms typical of the East African Rivers (notably *Barbus plagiostomus*) suggests water connexion to east, probably via the Omo River and Abyssinian highlands.

(3) The high proportion of endemic forms (nearly one-third of whole fauna) indicates a considerable period of isolation.

It remains to see how far these conclusions fit in with what is known of the recent geological history of the region. In the first place, earth movements associated with the formation of the Rift Valley in which Lake Rudolf lies have certainly played an important part, but their interpretation is not yet definite. It is therefore impossible to draw satisfactory conclusions, except that the movements continued at intervals through the tertiary epoch. The

* The Cichlidae of Lake Tanganyika are being revised by Dr. Tate Regan and Miss Trewavas and the non-Cichlidae by the present authors.

evidence from high-level beaches round the lake is more satisfactory : a very prominent beach, always between 350 and 450 feet above the present lake-level, has now been examined at a number of points round the basin, on both sides of the lake about half-way up its length by the 1930-1 Expedition, near the south end by Mr. Champion (1935), and in several other places by Mr. Fuchs's expedition (1935). This proves that since the beach was formed there have been no major earth movements to upset the drainage system, and it shows also that the old lake of great size must have had an outlet to maintain its level stationary for a long period. The high beach is dated as the early part of the Pleistocene, and, according to the faunistic evidence mentioned above, the outlet must have been north-west to the Nile rather than south to the smaller lakes of the Rift Valley, an interpretation which fits in with what is known of the geography of the region to the north-west. The conclusion that the endemic fish in Lake Rudolf have come into existence since early Pleistocene suggests a somewhat rapid rate of evolution, but the evidence from Lake Victoria and Lake Edward, which is analysed by S. and E. B. Worthington (1933, chaps. 14 & 15) suggests an even more rapid evolution.

Prof. J. W. Gregory (1921) postulated a gigantic lake, which he called Lake Kamasia, in the region where the Rift Valley now exists. It included Lake Baringo and the smaller rift lakes to the south. Leakey (1934), in bringing together evidence concerning the geography of East Africa during the pluvial periods, concluded that the great lake extended northwards to embrace Lake Rudolf also. No fauna, either fossil or living, showing affinities with the lower Nile, has yet been discovered south of Lake Rudolf, so at present the northward extension of the Pleistocene lake must remain an unproved conjecture. In the same paper Leakey postulated that the greater part of the East African Highlands were about 4,000 feet lower than at present, and he summoned evidence from the past glaciation or lack of glaciation on the peaks. Such a re-adjustment of levels would certainly make drainage connexions between the several basins easier to understand, but likewise it must be accepted at present with reserve.

If it is legitimate to look into the future as well as the past, the time can be foreseen when Lake Rudolf will be divided into two by sand-spits which are steadily extending towards the centre of the lake from opposite shores, one at the mouth of the Turkwel River on the west and the other at the foot of El Moitat (Moite) mountain on the east. Already the lake's width has been narrowed in this region from 20 to about 10 miles by sand-spit growth combined with lowering of water-level. If the presumed progressive desiccation continues there will be two closed drainage basins instead of one and the fish fauna in each will produce its own endemic forms until the alkaline water becomes so concentrated that fish-life will be impossible, and eventually only old lake beaches and a fossil nilotic fauna in a gypsiferous deposit will remain to show the past.

List of Lake Rudolf fish.

Name of species.	Lake Rudolf.	Nile system below Murchison Falls.	Elsewhere.
POLYPTERIDAE.			
<i>Polypterus bichir</i> Geoffr.	P (1)	P	Chad Basin, Nile system above Murchison Falls.
<i>Polypterus senegalus</i> Cuv.	P (1)	P	Chad, Senegal, Gambia, Niger.
MORMYRIDAE.			
<i>Gymnarchus niloticus</i> Cuv.	P (1)	P	Chad, Senegal, Gambia, Niger.
OSTEOGLOSSIDAE.			
<i>Heterotis niloticus</i> (Ehrenb.)	P (1)	P	Tropical Africa north of the Equator.
CHARACINIDAE.			
<i>Hydrocyon forskalii</i> Cuv.	P	P	Blue Nile, L. Margherita, Senegal, and Niger.
<i>Hydrocyon lineatus</i> Bleek.	P (2)	P	Tropical Africa, Blue Nile, Tanganyika, Niger, and Limpopo Rivers.
<i>Alestes dentex</i> (Linn.)	P (1)	P	Chad, Senegal, Gambia, Niger.
<i>Alestes baremose</i> (Joann.)	P	P	Blue Nile, Chad, Senegal, Gambia, Niger.
<i>Alestes nurse</i> (Rüpp.)	P	P	Blue Nile, Lakes Victoria and Kioga, Senegal to Cameroon.
<i>Distichodus niloticus</i> (Linn.)	P	P	
<i>Citharinus citharus</i> (Geoffr.) ....	..	P	Blue Nile, Chad, Senegal, Gambia, Niger.
Subsp. <i>intermedius</i> Worthington .	E (2)		
CYPRINIDAE.			
<i>Labeo horie</i> Heck.	P (2)	P	Blue Nile, Omo River.
<i>Barbus bynni</i> (Forsk.) ....	..	P	Blue Nile.
Subsp. <i>rudolfianus</i> Worthington .	E (2)		
<i>Barbus meneliki</i> Pellegr.	E (1)		
<i>Barbus plagiostomus</i> Blgr.	P (1)	..	Upper tributaries of Blue Nile and Hawash River.
<i>Barbus werneri</i> Blgr.	P (1)	P	Abaia, Rovuma River.
<i>Barilius niloticus</i> (Joann.)	P (2)	P	Blue Nile, Omo River, Niger.
<i>Engraulicypris stellae</i> Worthington .	E (2)		
<i>Engraulicypris bottegi</i> (Vincig.)	P (3)	..	Somaliland, S. Ethiopia, Omo River.

Name of species.	Lake Rudolf.	Nile system below Murchison Falls.	Elsewhere.
CLARIIDAE.			
<i>Clarias lazera</i> C. & V.	P (2)	P	Syria, Blue Nile, Senegal to Congo, Eusso Nyiro to River Molo.
SCHILBEIDAE.			
<i>Schilbe uranoscopus</i> Rüpp.	P (2)	P	Blue Nile, Uniamwesi and Ganana Rivers (East Africa).
BAGRIDAE.			
<i>Bagrus bayad</i> (Forsk.)	P (2)	P	Chad, Senegal, Niger.
<i>Auchenoglanis occidentalis</i> (C. & V.) .	P (1)	P	Blue Nile, Tanganyika, Mweru, and Bangweulu, Congo, Chad, Senegal, Niger.
MOCHOCHIDAE.			
<i>Synodontis schall</i> (Bl. & Schn.)	P	P	Blue Nile, Lakes Abaia and Stephanie, Chad, Senegal, Eusso Nyiro.
<i>Synodontis frontosus</i> Vaill.	P (1)	P	Omo River.
<i>Mochochus niloticus</i> Joann.	P (1)	P	
<i>Andersonia leptura</i> Blgr.	P (1) (2)	P	
MALOPTERURIDAE.			
<i>Malopterurus electricus</i> (Gmelin) ..	P (1) (2)	P	Tropical Africa—except Lake Victoria and E. African rivers north of the Zambesi.
CYPRINODONTIDAE.			
<i>Haplochromis rudolfianus</i> Worthington	E (2)		
<i>Haplochromis jeanneli</i> Pellegr. ..	E (1) (2)		
CENTROPOMIDAE.			
<i>Lates niloticus</i> (Linn.) .....	..	P	Blue Nile, Abaia (Abbaya), Congo, Chad, Senegal, Niger.
Subsp. <i>rudolfianus</i> Worthington .	E (2)		
Subsp. <i>longispinis</i> Worthington..	E (2)		
CICHLIDAE.			
<i>Tilapia nilotica</i> (Linn.)	P (2)	P	Syria, Blue Nile, Tanganyika, Chad, Senegal, Niger, Eusso Nyiro.
<i>Tilapia vulcani</i> Trewavas	E (2)		

Name of species.	Lake Rudolf.	Nile system below Murchison Falls.	Elsewhere.
CICHLIDAE (<i>cont.</i>).			
<i>Tilapia galilaea</i> (Artedi)	P (2)	P	Syria, Blue Nile, Senegal, Gambia, Lagos, Niger.
<i>Tilapia zillii</i> (Gerv.)	P	P	Syria, Lake Margherita, Chad, Niger, Gold Coast.
<i>Haplochromis rudolfianus</i> Trewavas.	E (2)		<i>Genus</i> otherwise only in W. Africa.
<i>Pelmatochromis exsul</i> Trewavas....	E (2)	..	
TETRODONTIDAE.			
<i>Tetrodon fahaka</i> Linn.	P (1) (2)	P	Chad, Senegal, Gambia, Niger.

P=Present.
E=Endemic.

- (1) Species not collected by Cambridge Expedition.
- (2) Species not previously recorded from Lake Rudolf.
- (3) Questionable record (see p. 372).

NOTE.—Only species which are known to inhabit the lake itself or the delta of the Omo River are included. A few other species, including *Alestes macrolepidotus*, occur in the Omo River and may subsequently be found in the lake.

Ecology.

Lake Rudolf has an area of some 3,600 square miles, a varied shore-line from gently shelving mud- or sand-flats to vertical cliffs, and a depth that ranges from a metre or so in the wide bays to at least 70 metres in the open water. There has been abundant opportunity, therefore, for the development of varied ecological associations. In working out the fish ecology, a first consideration is that of feeding habits and the distribution of food supply for each species. The data on feeding habits, which are given under the heading of each species, are based on a large number of stomach examinations. From these the food-chains in the lake have been worked out, and the positions of the important species are indicated in the accompanying diagram (fig. 1).

The character and quantity of the phyto- and zooplankton, on which the fish food supply depends to a large extent, was found to vary in different parts of the lake according to physical and chemical conditions*. Beadle (1932,

* Plankton investigations on Lake Rudolf have been submitted to quantitative analysis by the present authors in a paper which will follow in this series of scientific results.

pp. 184-92) has analysed the conditions, and there is no need to repeat the results here, except to indicate the two points of importance which influence the life of fish; these are:—

(1) Complete mixing of the water ensures the presence of sufficient oxygen throughout. Therefore fish and fish food can live at all levels right down to the bottom.

(2) The character of the water is different in the shallow gulfs, such as Ferguson Bay, from the open water. This reacts on the small plant and animal life, which is more abundant in the shallows, and therefore gives a more favourable environment for fish, especially for the microphagous species.

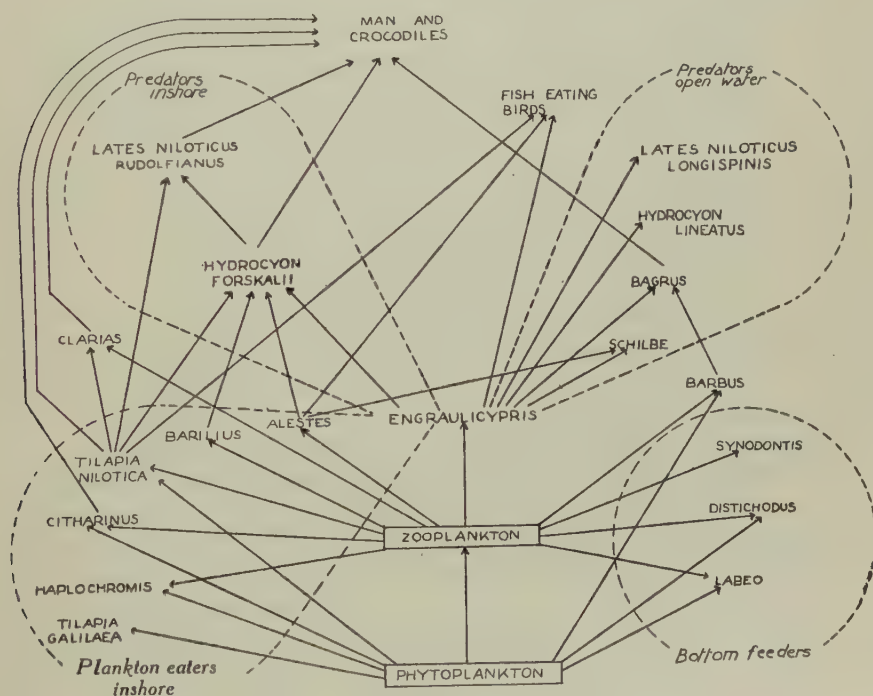


FIG. 1.—Food-chains in Lake Rudolf.

It is important, therefore, to dissociate life in the shallow bays from that in the open water, but since many species overlap both environments, no hard line can be drawn.

The fish can also be grouped according to the kind of food they eat. There are the predator forms, the plankton-eating forms, and the bottom-feeders. Of the six predators in Lake Rudolf, the small Nile Perch (*Lates niloticus*

longispinis), the large Tiger-fish (*Hydrocyon lineatus*), the Butter-fish (*Schilbe uranoscopus*), and the Cat-fish (*Bagrus bayad*) are characteristic of the open water, while only the large Nile Perch (*Lates niloticus rudolfianus*) and the small Tiger-fish (*Hydrocyon forskalii*) are found commonly in the shallows. Another Cat-fish (*Clarias mossambicus*), which is most abundant near the shores, may feed either as a predator or on zooplankton which it filters from the water by means of its long and closely-set gill-rakers.

There are eight important species of plankton-eaters and, except for *Engraulicypris stellæ*, they are mostly found in the shallows. There are forms which feed mainly on the zooplankton, like *Alestes baremose* and *A. nurse*, *Barilius niloticus* and *Engraulicypris*, then forms which feed both on the zoo- and phytoplankton, like *Citharinus citharus*, *Tilapia nilotica* and *Haplochromis rudolfianus*, and finally, those that eat the phytoplankton only, like *Tilapia galilæa*. Of all the fish in the lake *Engraulicypris stellæ*, although the smallest species, is probably the most important in the food economy. Abundant alike in shallow water and in the open, it serves as the central connecting link between the Crustacea of the plankton and the predator species.

The bottom-feeders live on debris, insect larvae and the plankton where the water is not too deep. *Barbus bynni* is generally found in the open water, while *Distichodus niloticus* and *Labeo horie* are restricted to the inshore waters. *Synodontis schall* appears to be omnivorous and to occur in large numbers all over the lake. It seems to be primarily a bottom-feeder, but wanders into the mid-water regions and even to the surface.

Haplochilichthys rudolfianus and *Pelmatochromis exsul* are small rare species living close to the shore among water-weeds or rocks, where microscopic fauna no doubt supplies their food.

Passing to the top-most links of the food-chain, all the larger and some of the small species may be eaten by man and crocodiles. In the diagram (fig. 1), however, arrows are drawn from only the six important species which offer good opportunities for development as human food. These are, in order of importance, the large *Lates*, *Citharinus*, *Tilapia nilotica*, *Bagrus*, *Clarias*, and *Hydrocyon forskalii*.

A special brief report on the possibilities of fishery development on Lake Rudolf is being submitted to the Kenya Government to accompany this paper.

Scheme for presentation of data for each species.

- (1) Scientific name ; English name ; Native (Turkana) name, if any.
- (2) *Distribution* of the species in other African waters, based on information given by Boulenger (1906-16), but brought up to date. This is given only in cases where there are points of interest in addition to the data shown in the list of fish on pp. 362-4.

Specimens from Lake Rudolf in the British Museum (Nat. Hist.).

- (3) *Habitat in Lake Rudolf*.

(4) *Size.*

(a) *Length.* Data are expressed as the total range of length and the average length, all based on field-measurements. The length of each fish was recorded in the log-books according to general fishery practice as the length in centimetres from the tip of the snout to the extremity of the caudal fin to the nearest cm. below the actual length. Therefore, to give true values, 0.5 cm. has been added whenever an average of a number of lengths is stated, and for length ranges 1.0 cm. has been added to the upper limit. It is important to notice that these figures are for 'total length', and include the caudal fin. The 'length' generally given in any systematic literature excludes the caudal fin.

(b) *Weight.* Field-weighings of fish are difficult and unsatisfactory; where reliable data are available they are included, using the metric system.

(c) *Condition Factor.* The relation of length to weight of a fish is expressed by the equation

$$100W = kL^3,$$

where

W = Weight in grammes,

L = Length in centimetres,

k = A constant known as the condition factor.

In general, the condition factor for a species is fairly constant, but certain changes take place during growth. Usually k increases gradually in the young stages, reaches a maximum just before breeding, then falls off. If the condition factor is known, it provides an easy method of converting the length records into weights. Values for k are given where there have been sufficient weight records.

(5) *Food.* These sections include data based on the examination of stomach contents.

(6) *Information regarding sexual development and breeding.*

This is usually given as:—

(a) The proportion of breeding to non-breeding fish.

(b) The numbers and size of breeding fish of each sex.

(c) Information about habits.

For the purposes of field records, gonad development was divided into the following stages:—(1) 'Undeveloped', implying that the gonads were not sufficiently mature for the sex to be determined. (2) Males or females, 'quiet'. (3) Males or females, 'starting', 'ripening', 'ripe', 'spent', implying that breeding was shortly to take place or had just done so. For the purposes of this paper, to simplify the presentation of data, the stages in the third category were grouped together as 'breeding'.

POLYPTERIDAE.

POLYPTERUS BICHR Geoffr. Tassel-fish.

No specimens from L. Rudolf in B.M. None col. Cambs. Exp.*.

POLYPTERUS SENEGALUS Cuv. Tassel-fish.

3 specimens in B.M. from Galeba, north-east end of L. Rudolf, col. Zaphiro-McMillan. None col. Cambs. Exp.

MORMYRIDAE.

GYMNARCHUS NILOTICUS Cuv.

1 specimen in B.M. from Galeba, north-east end of L. Rudolf, col. Zaphiro-McMillan. None col. Cambs. Exp.

OSTEOGLOSSIDAE.

HETEROTIS NILOTICUS (Ehrenb.).

1 specimen in B.M. from Galeba, north-east end of L. Rudolf, col. Zaphiro-McMillan. None col. Cambs. Exp.

CHARACINIDAE.

HYDROCYON FORSKALII Cuv. Small Tiger-fish. Lokel.

No specimens from L. Rudolf in B.M. previously. 10 col. Cambs. Exp.

Habitat in Lake Rudolf.—The small tiger-fish is probably abundant all over the lake, but it is much more in evidence in the shallow waters than in the open in accordance with its feeding habits and because it is persecuted by large predators in deep water. 59 specimens were caught, mostly along the shores in seines, but five were taken by gill-nets set at the bottom in open water, four from a depth of 18·5 metres and one from 60 metres.

Size.—29 measured specimens gave a total range of length from 5 to 59 cm. The average length of 13 adult fish, ranging from 34 to 59 cm. was 44·9 cm. No weights were recorded, but the figure of 0·42 for *k*, ascertained from Lake Albert specimens in 1928, can be taken as applicable.

Food.—This is definitely a predator. Of 10 stomachs of adult fish, of 34 to 58 cm. length, 2 were empty and the rest contained fish-remains, mainly small *Alestes* and *Tilapia*. 6 stomachs of young specimens from 7 to 13 cm. contained nothing but fish fry. 2 stomachs of very young fish only 5 cm. long contained *Cyclops* and a few fish fry.

The small Tiger-fish is perhaps the most important link between the small plankton-eaters like *Engraulicypris* and the large predator *Lates*.

Breeding.—The gonads of 20 specimens were examined, but they were all quiet. There were found to be four females from 45 to 59 cm., but the rest were too undeveloped for the sex to be determined. Small fry of 5 to 11 cm. in length were taken in the shallow water of Ferguson Bay.

* B.M. is used as an abbreviation for British Museum (Natural History), which contains the most representative collection of African fish. Col. Cambs. Exp. is an abbreviation for collected by the Cambridge Expedition.

HYDROCYON LINEATUS Bleek. Large Tiger-fish.

1 specimen from L. Rudolf in B.M., col. Cambs. Exp.

Habitat.—Although only 5 examples were caught, it is safe to conclude from analogy with Lake Albert that this species inhabits deeper water than the small Tiger-fish. The specimens were caught in the open water or near the steep shores on the east side of the lake.

Size.—4 measured specimens gave a range of lengths from 48 to 63 cm., with an average of 54·5 cm. One specimen of 48·5 cm. weighed 1·0 kg.

Food.—This is another predator. 4 stomachs contained fish-remains, mainly *Alestes*, *Barilius* and *Tilapia*. In one there were also a few pieces of weed.

Breeding.—No data, as the 4 examples examined were quiet.

ALESTES DENTEX (Linn.).

No specimens from L. Rudolf in B.M. None col. Cambs. Exp.

ALESTES BAREMOSE (Joannis). Dorobela.

No specimens from L. Rudolf previously in B.M. 4 col. Cambs. Exp.

Habitat.—This fish lives mainly in the inshore waters, where 14 were taken, but one specimen was caught 500 yards from the shore at the surface in Ferguson Bay.

Size.—4 measured specimens gave a range of lengths from 47 to 50 cm., with an average of 49 cm.

Food.—A plankton-eater. 2 stomachs were examined. 1 was empty and 1 contained zooplankton and a few pieces of water-weed. The zooplankton consisted chiefly of *Diaptomus*, *Cyclops*, *Diaphanosoma*, *Moina*, a few *Hyalodaphnia*, ostracods and water-mites.

Breeding.—There are no data about breeding as all the 10 specimens examined were quiet and in 7 the gonads were too undeveloped for the sex to be determined.

ALESTES NURSE (Rüpp.).

No specimens from L. Rudolf previously in B.M. 10 col. Cambs. Exp.

Pellegrin (1935, p. 133) examined 21 examples from L. Rudolf, col. Mission Scientifique de l'Omo, and concluded that they were the same as those described from the lake by Worthington (1932 *b*, p. 123). Since they differed in certain respects from typical *A. nurse*, he has called them a new variety—*nana*.

Habitat.—This fish lives along the sheltered shores of the lake.

Size.—The range of length was from 3 to 6 cm. This is a stunted form of *A. nurse* which only reaches about a quarter of its usual length.

Food.—A zooplankton-eater. 3 stomachs were examined and all contained large numbers of *Cyclops* and a few ostracods.

Breeding.—Examination of gonads showed that the fish were breeding in March.

DISTICHODUS NILOTICUS (Linn.). Gwolo.

1 specimen from L. Rudolf in B.M., col. Donaldson Smith. 1 head col. Cambs. Exp.

Habitat.—3 of the 4 specimens taken came from the shores of Ferguson Bay, while the fourth was caught $\frac{3}{4}$ -mile out at a depth of 18.5 metres.

Size.—4 measured specimens gave a range of lengths from 73 to 84 cm., with an average of 77.7 cm.

Food.—A bottom and weed feeder. 3 stomachs were examined. 2 contained ostracods, sand, shells and pieces of weed, and 1 contained in addition, a few algal filaments, several small gastropods and some chironomid larvae.

Breeding.—No data, as all the specimens were quiet.

CITHARINUS CITHARUS (Geoffr.) subsp. *INTERMEDIUS* Worthington. Agurt.

This subspecies is only from L. Rudolf.

5 specimens col. Cambs. Exp. in B.M.

Habitat.—*Citharinus* seems to be characteristic of intermediate water conditions where it is very abundant, and altogether 119 specimens were caught. It rarely occurs either in the rough open water or close to the shore, but large numbers were taken in gill-nets set within a radius of about a mile from the tip of Ferguson spit, both inside and outside the bay.

Size.—102 measured specimens gave a range of lengths from 39 to 65 cm., with an average of 53.7 cm.

Food.—Plankton-eater. 3 stomachs were examined and all contained planktonic plants including *Hormidium*, desmids and other algae, a few *Diaptomus*, ostracods and rotifers. The presence of sand and detritus shows that this fish feeds at or near the bottom, but it can also feed on the surface scum which it skims off with its wide mouth.

Breeding.—The gonads of 68 specimens were examined, and it was found that the sexes were of the same size, but that there were nearly twice as many females as males. All the fish were quiet, with the exception of two males which were preparing to breed. This suggests that there must be a definite breeding season and that it does not occur during the first three months of the year.

CYPRINIDAE.

LABEO HORIE Heckel. Chibule.

11 specimens from L. Rudolf, col. Cambs. Exp. in B.M.

Habitat.—This fish is well distributed in Ferguson Bay, where 18 of the 24 specimens were taken.

Size.—17 measured specimens gave a total range of length from 9 to 83 cm. The range for 9 adults was from 62 to 83 cm., with an average of 73.8 cm. 2 specimens of 65.5 cm. and 74.5 cm. length weighed 2.7 and 5.2 kg. respectively, and the value of *k* for the 2 fish is calculated to be 1.15,

Food.—A bottom-feeder. 13 stomachs were examined. 8 contained microscopic plants, and 5 ostracods, pieces of weed and sand.

Breeding.—15 specimens were examined and found to be quiet, except for 1 male of 62.5 cm. which was starting, and in 8 the gonads were too undeveloped for the sex to be determined. Young fry were caught along the sandy shores.

BARBUS BYNNI (Forsk.) subsp. *RUDOLFIANUS* Worthington. Barbel. Toto Chibule.

This subspecies is known only from L. Rudolf.

4 specimens col. Cambs. Exp. in B.M.

Habitat.—14 of these fish were taken in gill-nets set at the bottom, 7 at a depth of 18.5 m. in Ferguson Bay and 7 at 19.8 m. in the open water of the lake.

Size.—14 measured specimens gave a range of length from 27 to 51 cm., with an average of 37.8 cm.

Food.—This is mainly a bottom-feeder. 7 stomachs were examined. 3 were empty, 3 contained mud, and 1 ostracods, sand, small algae and chironomid larvae.

Breeding.—There are no data as all the specimens were quiet, and in 10 the gonads were too undeveloped for the sex to be determined.

BARBUS MENELIKI Pellegr.

Endemic in Lake Rudolf, known only from the type in the Paris Museum.

None col. Cambs. Exp.

BARBUS PLAGIOSTOMUS Blgr.

No specimens in B.M. from L. Rudolf. None col. Cambs. Exp.

BARBUS WERNERI Blgr.

1 specimen from L. Rudolf in B.M. col. Donaldson Smith. None col. Cambs. Exp., 6 specimens from Omo R. and its delta col. Mission Scientifique de l'Omo in Paris Museum.

BARILIUS NILOTICUS (Joannis).

5 specimens from L. Rudolf col. Cambs. Exp. in B.M.

Habitat.—This species lives only in very shallow water close to the shore.

Size.—The range of length was from 3 to 5 cm.

Food.—4 stomachs were examined and found to contain *Diaptomus* and remains of a few other Crustacea, sand-grains and the head of an insect.

Breeding.—No data.

ENGRAULICYPRIS STELLAE Worthington.

109 specimens col. Cambs. Exp., 19 in B.M.

Habitat.—This is probably the most abundant fish in Lake Rudolf. It occurs both in the shallow inshore waters and also out in the open lake, where shoals can often be seen swimming near the surface.

Size.—The lengths ranged from 2 to 3 cm.

Food.—Plankton-eater. 7 stomachs of fairly large specimens contained mainly ostracods, a few other Crustacea and numerous minute algae. These specimens were from Ferguson Bay, where ostracods are very abundant. 20 stomachs of small fish contained mainly *Diaptomus*, nauplii and minute algae. In several there were ostracods, rotifers and sand, and in one, large numbers of desmids and of a ciliate protozoan were present. This small fish is a most important member of the fauna, partly because of its abundance, but mainly because it feeds on the zooplankton and thus acts as a link between the plankton and the predator fish.

Breeding.—Fish of 2.2 cm. in length were found to be mature.

ENGRAULICYPRIS BOTTEGI (Vincig.).

No specimens from L. Rudolf in B.M.

In 1895 Vinciguerra described some small fish from Auata as *Neobola bottegi*. These are now known as *Engraulicypris bottegi*. A few years later he was given six specimens of 3.5 cm. length, from Lake Rudolf, and he called these also *Neobola bottegi*. Later, specimens attributed to the same species have been found in the Omo and several other rivers.

All the *Engraulicypris* caught in Lake Rudolf by the Cambridge Expedition were found to be a new species, *E. stellae*, intermediate in some respects between *E. bottegi* and *E. minutus*. It is unlikely that there are two small species of *Engraulicypris* living in the lake, so it seems probable that the six specimens attributed to *E. bottegi* really belong to *E. stellae*. There has not been an opportunity yet of examining the old specimens, so *E. bottegi* is included in the list as a questionable record.

CLARIIDAE.

CLARIAS LAZERA Cuv. & Val. Cat-fish. Obito.

4 specimens and 2 heads from L. Rudolf col. Cambs. Exp. in B.M.

Habitat.—This fish probably occurs all over the lake, but none were ever taken in the deep water. It was either seen or caught round every type of shore-line, including the rocky shore of central island. Like *Tilapia*, it is also common in the Crater Lakes of the Island. 17 specimens were taken.

Size.—3 measured specimens gave a range of lengths from 59 to 64 cm., with an average of 61.1 cm.

Food.—2 stomachs of fish from shallow water close to the rocky shore of Central Island contained large numbers of Crustacea, mostly *Diaptomus* and *Cyclops*, and also a few insect remains and chironomid larvae. The presence of open water plankton in these fishes close to the land is explained by the fact that the shore slopes so steeply that open water forms are brought directly into contact with the land. The examination of these stomachs shows that *Clarias* is able to use its long and closely-set gill-rakers for filtering Crustacea

and can thus feed on the plankton. This has been shown previously for the same species in Lake Albert and for *C. mossambicus* in Lake Victoria.

1 stomach of a fish from Crater Lake A, where planktonic Crustacea are scarce, contained only remains of *Tilapia*, showing that *Clarias* can also feed as a predator.

Breeding.—2 of the 3 specimens examined were ripening females of 60.5 cm. and 63.5 cm. taken from near Central Island. No males were caught.

SCHILBEIDAE.

SCHILBE URANOSCOPIUS Rüpp. Butter-fish. Naili.

It has been pointed out by Worthington (1932 *b*, p. 129) that the Rudolf form of this species is intermediate in some characters between *S. uranoscopus* and *S. mystus*. The former was previously known from the Nile below Bahr-el-Jebel and the Uniamwesi and Ganana Rivers of East Africa, while *S. mystus* has a much wider distribution, including the Nile and nearly all tropical Africa.

5 specimens from L. Rudolf col. Cambs. Exp. in B.M.

Habitat.—This fish lives mainly in the open waters, though one was caught in Ferguson Bay. Most of the 16 specimens taken were caught in gill-nets set at the bottom in open water or in nets set near the surface off exposed lee-shores.

Size.—16 measured specimens gave a range of lengths from 26 to 40 cm., with an average of 33.4 cm.

Food.—A predator. 9 stomachs were examined. 3 were empty, 2 contained small *Alestes*, 1 the remains of a very young *Tilapia* and in 3 were unrecognizable remains of small fish, probably *Engraulicypris*.

Breeding.—All the 15 specimens examined were found to be females with undeveloped gonads. The males of *Schilbe* species are much smaller than the females and may have escaped through the meshes of the nets.

BAGRIDAE.

BAGRUS BAYAD (Forsk.). Cat-fish. Lorok. Lorogo.

2 specimens from L. Rudolf col. Cambs. Exp. in B.M.

Habitat.—*Bagrus* was caught in gill-nets at nearly every station in the open water, including a bottom fishing at a depth of 60 m. It was rarely caught in the sheltered waters of Ferguson Bay, but there is some indication that it comes into the shallow water to breed. Altogether 28 specimens were taken.

Size (N.B.—The caudal filament is not included in the lengths.).—12 measured specimens gave a range of lengths from 59 to 88 cm., with an average of 73.2 cm. The table on p. 374 shows records of weights and condition factors, and indicates the steady increase of condition factor with size.

Breeding.—11 specimens were examined, but only 3 had developing or ripening gonads, and these came from Ferguson Bay. One was a male of

	No. of fish.	Range of length.	Average length.	Average weight.	Average <i>k</i> .
	* 30	36–52 cm.	41 cm.	0·4 kg.	0·58
	2	59–61 „	60 „	1·35 „	0·62
	4	73–81 „	75·7 „	3·0 „	0·69
	1	87 „	87·5 „	4·75 „	0·71
Mean of totals of Lake Rudolf fish.	7	59–87 cm.	72·9 cm.	2·8 kg.	0·67

72·5 cm. caught in a seine close to the sandy shore, and the other two were females of 59·5 and 87·5 cm. caught in the shallow water of only 3 metres in the middle of the Bay.

AUCHENOGLANIS OCCIDENTALIS (Cuv. & Val.).

No specimens from L. Rudolf in B.M. None col. Cambs. Exp.

MOCHOCHIDAE.

SYNODONTIS SCHALL (Bloch-Schneid.). Tirr.

3 specimens from Sagan River, L. Rudolf, previously in B.M. col. Zaphiro-McMillan. 7 col. Cambs. Exp.

Habitat.—*Synodontis* is one of the most abundant fish in the lake and 258 specimens were taken. It was caught in large numbers both in the open water and in Ferguson Bay. At one station (277) 114 fish were caught in three gill-nets of 7", 5" and 3" mesh. Specimens were caught in nets set at the surface and also at the bottom in depths of 18·5 and 19·8 metres, but none were caught in a bottom fishing at 60 metres.

Size.—207 measured fish gave a range of lengths from 16 to 43 cm. The average length of 157 specimens was 32·3 cm. The table on p. 375 shows the average weight and condition factor for 113 weighed fish.

It is notable that the value for *k* in this fish decreases with increase of length, whereas in most species *k* increases with length. This shows that *Synodontis* becomes proportionately longer and thinner in the adult than in the young, instead of shorter and deeper as in most other forms.

Food.—Omnivorous. 81 stomachs were examined. 60 were empty. 16 contained ostracods and a few *Cyclops*, 3 zooplankton, fish-remains and prawns, 1 many small gastropods and in 1 the contents were unrecognizable.

* Data from Lake Albert for the same species (Worthington, 1929, p. 81).

Breeding.—45 of the 142 fish examined were found to be breeding or preparing to breed. Of these only 2 were caught in open water, while the rest came from Ferguson Bay. This suggests that breeding takes place in comparatively shallow and sheltered waters. The sexes are approximately equal in numbers

	No.	Range of lengths.	Average length.	Average weight.	Average <i>k</i> .
	5	20-25 cm.	23 cm.	0.2 kg.	1.64
	50	25-30 "	28 "	0.27 "	1.23
	48	30-35 "	33 "	0.37 "	1.03
	10	35-40 "	38 "	0.53 "	0.97
Average of totals.	113	20-41 cm.	30.5 cm.	0.33 kg.	1.22

and in size. The range of length of 19 breeding females was from 25 to 41 cm., with an average of 33.2 cm. The range for 26 breeding males was also from 25 to 41 cm., with an average of 33.1 cm.

No young fry were caught, but some half-grown fish from 16 cm. upwards were taken in the bay in company with the adults.

SYNODONTIS FRONTOSUS Vaill.

3 specimens from Galeba, north-east end L. Rudolf, col. Zaphiro-McMillan. None col. Cambs. Exp.

MOCHOCHUS NILOTICUS Joannis.

No specimens from L. Rudolf in B.M. and none col. Cambs. Exp.

ANDERSONIA LEPTURA Blgr.

No specimens from L. Rudolf in B.M. and none col. Cambs. Exp. 2 specimens from Omo delta col. Mission Scientifique de l'Omo in Paris Museum.

MALOPTERURIDAE.

MALOPTERURUS ELECTRICUS (Gmelin).

No specimens from L. Rudolf in B.M. and none col. Cambs. Exp. 1 specimen from Omo delta col. Mission Scientifique de l'Omo in Paris Museum.

CYPRINODONTIDAE.

HAPLOCHILICHTHYS RUDOLFIANUS Worthington.

4 specimens col. Cambs. Exp. in B.M.

Habitat.—This fish only occurs in shallow weed-grown waters. Since there is very little of such shore-line round L. Rudolf, it is not an important member

of the fauna. Four specimens only were taken, three from Ferguson Bay and one from the east shore near El Moitat mountain.

Size.—Range of lengths from 17 to 27 cm.

HAPLOCHILICHTHYS JEANNELI Pellegrin.

No specimens in B.M.

5 specimens from Omo delta col. Mission Scientifique de l'Omo in Paris Museum.

CENTROPOMIDAE.

LATES NILOTICUS (Linn.) subsp. RUDOLFIANUS Worthington. Nile Perch. Idgi.

This subspecies is peculiar to L. Rudolf.

11 specimens col. Cambs. Exp. in B.M.

Habitat.—This is the large subspecies of *Lates niloticus* which appears to live in the bays and inshore waters, and rarely wanders out into the open lake. At the bottom in the deep open water it is replaced by the much smaller *L. niloticus longispinis*. Most of the 63 specimens of the large form were taken near steeply shelving banks of sand, either adjoining the shore or where under-water sand-spits abut on deep water. In these places *Lates* can lurk unseen near the shallows and has the best chance of catching *Hydrocon*, *Tilapia* and the other medium-sized fish which go to form its diet. Occasionally enormous specimens were seen basking close to the surface up to half a mile out in the open water. At one station (215) in a bottom fishing at a depth of 18.5 m., a half-grown specimen of 86 cm. was caught in a gill-net together with a fish of the other subspecies. This suggests that the larger form may sometimes wander out into deep water and invade the habitat of the smaller.

In Lake Albert it was also found that there were two types of *Lates*, a very large species, *L. albertianus*, living in the shallow water and a much smaller species, *L. macrophthalmus*, in the deep water (see Worthington, 1929, pp. 85–90). These were both described as new species, and certainly they differ more markedly from typical *L. niloticus* from the Lower Nile than do the two subspecies in Lake Rudolf. Now that the policy of using subspecies for some of the African fish has been adopted, however, the Lake Albert forms, like those from Lake Rudolf, are best regarded as subspecies of *L. niloticus*. The splitting up of *Lates* into two forms in each of these lakes independently is a peculiarly interesting case of the possible effect on evolution of difference in habitat.

Size.—54 measured specimens gave a total range of length from 11 to 190 cm. The average length for 49 fish ranging from 38 to 190 cm. was 100.2 cm. The range for males was from 31 to 103 cm., but specimens less than 60 cm. long were immature. For females the range was 35 to 190 cm., specimens less than 80 cm. being immature. Data about 23 adults are given in the table on p. 377. The most striking fact shown is the difference in size of the two sexes. The largest male was only 102.5 cm. in length compared with 189.5 cm. for the largest female. The greatest weight for a male was 13.1 kg. compared with

95.5 kg. for a female. Worthington (1929, pp. 88, 89) presented closely similar data for *L. albertianus* in Lake Albert. The largest male was 105 cm. long and weighed 13 kg.; the largest female was 165 cm. long and weighed 52.7 kg. At Sennar on the Nile, Kenchington* also found a difference in size between the sexes in *L. niloticus*, but it was not so marked. His largest male measured 119 cm. and weighed 16.8 kg., while the largest female measured 150.4 cm. and weighed 47.7 kg.

The condition factor for individual fish from L. Rudolf varies between fairly wide limits, from 1.19 to 1.37 for males and from 1.13 to 1.55 for females. Kenchington found an even larger range from 0.74 to 1.8, the value for the males tending to be higher than for females. The table below shows that the condition factor is considerably higher for breeding than for quiet females. The data from Lake Albert and from Sennar referred to above show the same result.

Males.					Females.			
Length in cm.	No. of fish.	Average weight in kg.	Average k.	Breeding or quiet.	No of fish.	Average weight in kg.	Average k.	Breeding or quiet.
60-70	1	4.5	1.37	Breeding.				
70-80	..	..	..		
80-90	1	9.5	1.35		1	9.3	1.32	
90-100	3 †	11.7	1.26	Quiet.	3	10.6	1.21	
100-110	1 †	13.1	1.3		5	14.8	1.28	
110-120	..	..	..		1	15.0	1.13	
120-130	..	..	..	..	1	25.0	1.17	Quiet.
130-140	..	..	..	..	..	..	..
140-150	..	..	..	..	..	..	..
150-160	..	..	..	..	2	57.8	1.42	Breeding.
160-170	..	..	..	..	2	62.0	1.47	
170-180	..	..	..	..	1	76.0	1.55	
180-190	..	..	..	..	1	95.0	1.41	Spent.
Totals.	No.	Average weight.	Average k.	Average length.	No.	Average weight.	Average k.	Average length.
Quiet	2	12.5	1.3	100	12	17.0	1.25	107.8
Breeding .	4	9.25	1.3	88.5	5	70.4	1.47	168.5

N.B.—The totals are worked out from the actual field-data and not from the averages given in the table above.

Food.—A predator. 48 stomachs were examined, of which 41 were empty. 4 contained unrecognizable remains of fish, 2 remains of *Tilapia* up to 25 cm.

* Paper not yet published.

† Including fish whose weights were estimated, taking k as 1.3.

in length, and one, a very large *Lates* of 160 cm., had eaten a young specimen of the same species 38 cm. long. In Lake Albert young *Lates* from 3 to 8.7 cm. in length were found to have eaten prawns and very small fish. It is probable that this also applies to the young fish in Lake Rudolf, though no data that show it were actually collected.

Breeding.—49 specimens of over 44 cm. were examined, and it was found that females outnumbered males by 35 to 14, but of these only 7 females and 8 males had gonads in a well-developed condition. The Lake Albert data for *L. albertianus* showed a still greater preponderance of 36 females to 9 males. Kenchington, however, who examined more specimens, found that the sexes of *L. niloticus* were about equal in numbers. The striking difference in size between males and females has been pointed out above.

A few young fry under 10 cm. in length were taken in the trawl on a muddy bottom in 3 or 4 metres of water in Ferguson Bay. Young fish were also caught in the weedy shallows near Mount El Moitat on the east shore of the lake. It may be noted that in Lake Albert the fry of *L. albertianus* were taken in large numbers at the bottom in depths of 6 to 10 metres. No young *Lates* were caught in similar depths in Lake Rudolf, though several attempts were made to see if they occurred there.

LATES NILOTICUS (Linn.) subsp. LONGISPINIS Worthington. Nile Perch.

This subspecies is only from L. Rudolf.

6 specimens col. Cambs. Exp. in B.M.

Habitat.—This subspecies lives only near the bottom in the deep open water. Six specimens were caught in weighted gill-nets, four from a depth of over 50 m. and two from 18.5 m.

Size.—5 measured specimens gave a range of length from 14 to 36 cm.

Food.—3 stomachs were examined. 1 was empty, 1 contained many adult prawns and 1 from 18.5 metres the remains of a small fish and a dragonfly nymph.

Breeding.—There is little information about this species, but all three fish examined were breeding or preparing to breed. The only male caught was 31.5 cm., as compared with 35.5 cm. for the largest of the two females. This suggests that there is probably no marked difference in the size of the sexes.

CICHLIDAE.

TILAPIA NILOTICA (Linn.). 'Carp.' Rogene.

18 specimens from L. Rudolf, col. Cambs. Exp. in B.M.

Habitat.—This fish is abundant in the lake and 277 specimens were taken, but it is restricted to the inshore waters, apparently by the large predators, especially *Lates*. It occurs in large numbers along the sheltered sandy beaches, where it is caught by Turkana natives in large 'plunge baskets'. It is probable

that from time to time shoals of these fish wander out into the deep water. On one occasion, on the east shore under Mount El Moitat, several shoals were seen at the surface a few hundred yards from the shore. The shoals were perfectly circular in shape with a diameter of about 10 feet, and each contained several hundred adult fish swimming round and round the edge in the same direction. This curious type of shoal has also been recorded for *Tilapia galilaea* in the Sea of Galilee, and there the shoals were over an acre in extent (Norman, 1931). It is difficult to explain this behaviour, but it suggests some association with the breeding habits.

Enormous numbers of a stunted dwarf race of *Tilapia nilotica* occur in Crater Lake C of Central Island. Though sexually mature, these never exceed a length of 18.5 cm., while in the main lake the fish reach a maximum of 64 cm. This phenomenon of dwarfing of *T. nilotica* in restricted environments has been observed before, particularly in some of the lagoons cut off by sand-spits near the shores of Lake Albert (see Worthington, 1929, p. 91). *Tilapia nilotica* is remarkably tolerant of hot-water conditions. Numbers of young specimens swarm in the shallow waters where the afternoon temperature may reach 35° C. or even higher, and one specimen was taken in a hot spring near the Turkwel River at about 40° C.

Size.—145 measured specimens gave a total range of lengths from 3 to 64 cm. The average length of 84 fish ranging from 11 to 64 cm. was 39.4 cm. One specimen of 44.5 cm. length weighed 2.5 kg. and gave a value for *k* of 2.84.

Food.—16 stomachs were examined. 2 were empty, 5 contained phytoplankton including *Hormidium*, 5 similar phytoplankton with *Diaptomus*, *Cyclops* and a few Cladocera in addition, 3 chewed weed and 1 fish-remains.

Breeding.—The number of males exceeded that of females by 33 to 19, but only 15 specimens were found to be breeding. Males were larger than females. The range of lengths of 10 breeding males was from 29 to 64 cm., with an average of 54 cm., while the range for 5 breeding females was from 32 to 43 cm., with an average of 39.1 cm.

All the African species of *Tilapia* seem to have similar nesting habits. A nest, sometimes over a yard in diameter, is hollowed out by the male in the sand in water of only a few feet in depth. The female then lays her eggs in the nest and they are fertilized by the male. After fertilization the eggs are taken into the mouth of the female until their development is complete, and even afterwards the young fry return to her mouth in times of danger. When they are finally liberated, the young fish live in the very shallow water close to the shores, where they swim about in shoals. Many young fry were seen along the shores of Ferguson Bay and also in the muddy lagoons which had become shut off from the lake by the lowering of the water-level. Large numbers of *Tilapia* nests were seen along the gently shelving sandy beaches of Ferguson Bay. The Turkana natives often mark the nests with sticks and visit them from time to time to catch the fish in them.

TILAPIA VULCANI Trewavas.

Only known from Crater Lake A, Central Island, Lake Rudolf.

7 specimens col. Cambs. Exp. in B.M.

Habitat.—Miss Trewavas (1933, p. 316) pointed out that this species has probably been split off from *T. nilotica* and that it may correctly be only a subspecies. It is clear from the geography of the island that Crater Lake A was joined to the main lake until quite recently. At the present time it is only separated by a bank about 20 feet high, and this bank shows signs of recent subaqueous erosion. It is agreed that since Lake Rudolf was discovered in 1888, there has been a fairly steady fall in the level of the water, sufficient to dry up Saunderson's Gulf at the north end of the lake and to isolate Crater Lake A. The lake-level must have dropped considerably over 20 feet in the last fifty years or so, and the evolution of *T. vulcani* from *T. nilotica* must therefore have taken place within this time.

Size.—12 measured specimens gave a range of length from 15 to 32 cm., with an average of 27.9 cm.

Food.—3 stomachs were examined and all contained small pieces of chewed vegetation and much unrecognizable debris.

Breeding.—2 of the 11 specimens examined were quiet and the rest were males either breeding or preparing to breed. Their lengths ranged from 25 to 32 cm., with an average of 29 cm.

TILAPIA GALILAEA (Artedi). 'Carp.'

6 specimens from L. Rudolf, col. Cambs. Exp. in B.M.

Habitat.—This species has a habitat similar to that of *T. nilotica*, but it is not nearly so abundant and only 6 specimens were taken. None were seen or caught more than a few hundred yards from the shore.

Size.—4 measured specimens gave a range of lengths from 22 to 29 cm., with an average of 25.7 cm.

Food.—Phytoplankton-eater. 5 stomachs were examined and all contained microscopic plants only.

Breeding.—No data, as all the 4 fish examined were quiet. There were 3 females and 1 male.

TILAPIA ZILLII (Gervais).

1 specimen in B.M. from L. Rudolf col. Donaldson Smith. 4 specimens col. Cambs. Exp.

Habitat.—This fish was only caught close to the shore, where it was taken in nets with *Tilapia nilotica* and *Tilapia galilaea*.

Size.—4 measured specimens gave a range of lengths from 12 to 20 cm.

HAPLOCHROMIS RUDOLFIANUS Trewavas.

5 adults and 25 young col. Cambs. Exp. in B.M.

Habitat.—This fish lives close to the shore in very shallow water. It was

taken in only 2 places, by the steep rocky shore of Central Island and in a little weedy bay on the east shore under El Moitat.

Size.—The lengths ranged from 2 to 6 cm.

Food.—The stomach of the fish from Central Island contained open-water planktonic Crustacea*, mainly *Diaptomus*, a few *Cyclops* and Cladocera, also numerous desmids, several *Botryococcus* and a few insect-remains. The stomachs of two of the fish from the weedy bay contained mainly microscopic plants, including numerous desmids and other algae, also a few ostracods, sand-grains and insect-remains.

Breeding.—No data.

PELMATOCHROMIS EXSUL Trewavas.

The genus *Pelmatochromis* was known previously only from West Africa, and Miss Trewavas (1933, p. 321) has pointed out that the L. Rudolf species is closely related to *P. kribensis* and *P. caudifasciatus* from South Cameroon. This is an interesting example of discontinuous distribution, and lends some support to the theory that the Lower Nile region was at one time in communication with the Chad Basin and the West African rivers by a water-connection across the Southern Sahara.

3 specimens col. Cambs. Exp. in B.M.

Habitat.—Similar to *Haplochromis rudolfianus*, but only 3 specimens were caught.

Size.—The lengths ranged from 2 to 5 cm.

Food.—1 stomach was examined and found to contain many insect larvae and the remains of a few adult insects.

Breeding.—No data.

TETRODONTIDAE.

TETRODON FAHAKA Linn. Puffer-fish.

Small Puffer-fish have been observed at the south end of Lake Rudolf by one or two travellers, and Mr. R. E. Dent, fish warden in Kenya, has a specimen from the lake. It has not been examined by the present authors, but is almost certainly the Nile species.

There are no specimens from L. Rudolf in the B.M.

LAKE BARINGO.

History of investigations.

Lake Baringo was discovered by Joseph Thompson in 1883. In 1888 it was visited by Count Teleki and von Höhnelt on two occasions, on the way to and from Lake Rudolf during their exploratory journey. The first fish were collected

* Cf. *Clarias lazera*. Open-water plankton is found close to the steep shore of Central Island.

in 1893 by Professor J. W. Gregory when he brought back specimens of *Barbus*. In 1906 more specimens of *Barbus* and some *Labeo* were collected by Sir H. H. Johnston. Sir F. J. Jackson also went to the lake between 1911 and 1916 and collected a small specimen of *Clarias*. In 1929 Miss Jenkin visited the south end of the lake and studied the water chemistry and plankton. The Cambridge Expedition made two visits to the lake—in December 1930 and January–February 1931, each of about a week's duration—and investigated the ecology and fish resources.

Physical conditions.

Lake Baringo is about 12 miles long and 5 miles wide, and lies in the Rift Valley, about 140 miles to the south of Lake Rudolf. It has a remarkably uniform depth of about seven and a half metres, shallowing somewhat in the northern half. There are several volcanic plugs of Pleistocene age which stand up from the lake floor as rocky islands. The largest, Ol Kokwa, is about a mile and a half square and is inhabited by a section of the local tribe, called the Njemps, who transport large quantities of fish to the mainland for sale and barter.

Beadle (1932, pp. 178–83) has given an account of the water conditions, but for convenience the following points may be noted. The lake lies in its own drainage basin with no obvious outlet. The water comes mainly from two small rivers at the south end and also from some hot springs on the island Ol Kokwa. Although the water from the springs is very alkaline, 0.032 Normal, the water of the lake itself is relatively fresh, 0.0057 N., proving that there is an under-water outlet. Such an outlet at the north end was actually observed by Gregory.

The lake is situated at an altitude of 3,150 feet, so that the climate is more temperate than near Lake Rudolf, but hot and dry compared with the Rift Valley further south in the neighbourhood of Lake Naivasha. The water supports a dense phytoplankton mainly of blue-green algae, which renders the water very opaque. Consequently the extreme surface may become heated at mid-day to as much as 30° C., although from a metre's depth to the bottom the temperature is practically uniform at about 23.6° C. At night surface cooling causes complete mixing of the water, and this mixing is assisted by intermittent winds, so that oxygen is always abundant at all water-levels.

Affinities of the fish fauna.

Only four species of fish were found in Lake Baringo, and these are all forms well known from other parts of Africa. Two species, *Labeo cylindricus* and *Barbus gregorii*, occur chiefly in the East African rivers, while the other two, *Clarias mossambicus* and *Tilapia nilotica*, are more widespread. The *Clarias* occurs over most of East Africa, including Lakes Victoria and Tanganyika, while the *Tilapia*, though typical of the Nile System and West Africa, is also present in some of the East African rivers. Trewavas (1933, p. 314) has pointed

out that the *Tilapia*, though it must be identified with the species *nilotica*, is not truly typical.

Since Lake Baringo is completely isolated at the present time, the presence of these fish can only be explained by assuming that there has been a change in the physiography of the region. Gregory (1921) showed that the part of the Rift Valley in which Lake Baringo lies was once occupied by a vast lake which he named Lake Kamasia. Fuchs (1934) concluded, on geological grounds, that since Kamasian times Lake Baringo must have drained northward to Lake Rudolf via the Sugota River, and still does to this day by seepage through the lavas. Leakey (1934) postulated that Lake Kamasia extended in early Pleistocene times over most of the region which now forms the Rift Valley and some other parts of East Africa as well. It is doubtful exactly how large Lake Kamasia was, but it is clear that at the end of its history the great lake was broken up into a chain of smaller lakes by uplift of the land in the centre of the area.

One explanation of the origin of the fauna of Lake Baringo, therefore, might be that it is derived from the fauna of Lake Kamasia, but if this lake extended northward to embrace the valley of Lake Rudolf, it must surely have had a nilotic fauna. Furthermore, if the fish of Lake Baringo had been isolated since early Pleistocene times, they would have become altered and given off endemic species like those in nearly every other East African lake. There are, however, no endemic species in Lake Baringo, and the few species which do exist are scarcely modified.

Another explanation for the presence of these fish is that they came from the East African rivers, which drain to the Indian Ocean, after the lake had been isolated. This seems likely, since all the Lake Baringo species occur in one or other of the East African rivers. Even now the heads of these rivers lie very near the Rift Valley Lakes, and in particular the tributaries of the River Tana come close to Lake Baringo. If the country in the past were lower and wetter than at the present time it might be possible for the fish to cross the water-sheds. Also, there is evidence of recent river capture in the region in question, which supports this contention. It seems probable, therefore, that the colonization of Lake Baringo by fish only took place relatively recently, and that for a long period after its isolation the lake stood empty, or, being shallow it may have dried up in the arid interpluvial periods.

Ecology.

The open water of Lake Baringo is very uniform, and the lack of deep water offers little opportunity for the differentiation of species associations. The shore-line is varied, from gently shelving sand to boulders or small cliffs, while the southern end is bounded by a swamp. This variety of shore does not reflect on the fish, however, for all four species were found inshore as well as in the open water. On the whole, the smaller and younger fish were more abundant close to the shore.

The principal food-supply in the lake is the very dense phytoplankton, mainly *Microcystis*. Together with this is a relatively scarce zooplankton. The highly organic bottom deposit supports a rich life of chironomid larvae. No water-weeds were found, except in the swamp at the south end, but along sandy shores the reed, *Paspalidium geminatum*, growing in water of 1 to 5 feet

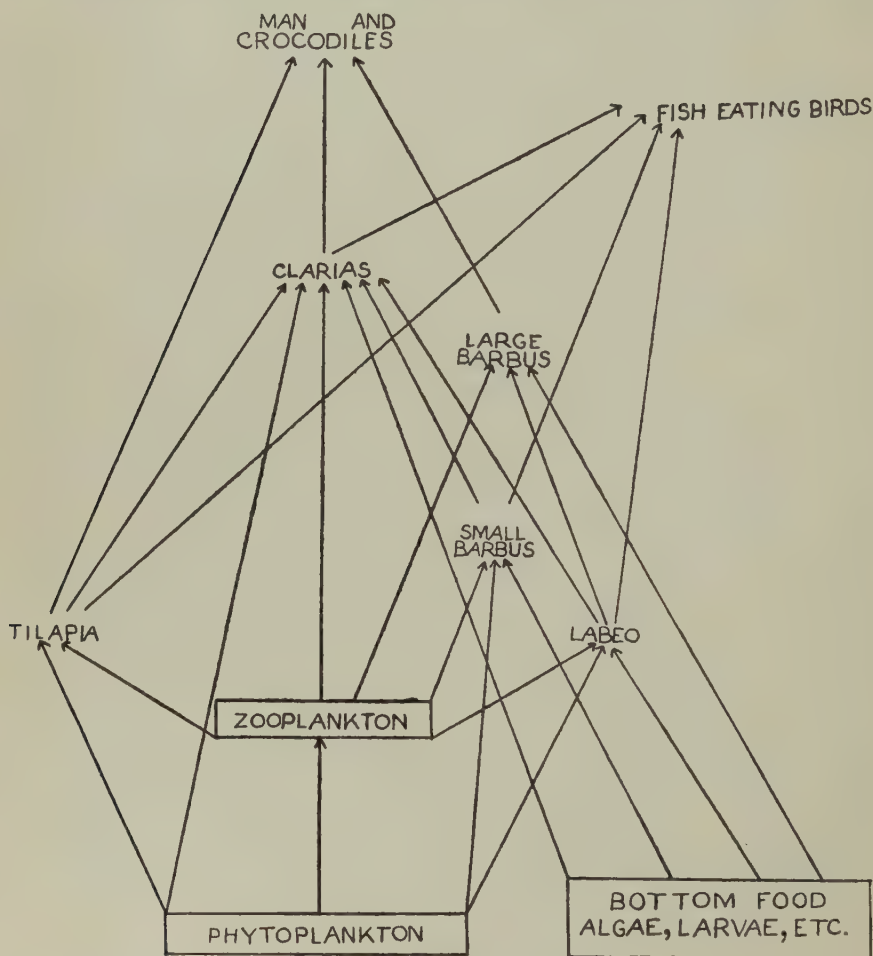


FIG. 2.—Food-chains in Lake Baringo.

depth, is important in providing considerable insect-food, particularly dragon-fly nymphs.

Of the fish there are two predators, the adults of *Barbus* and *Clarias*, though both are to some extent omniverous. There are two plankton-eaters, *Tilapia* and the young *Barbus* and one bottom-feeder, *Labeo*. Owing to the shallowness

of the water, mud and sand-grains and a certain amount of food from the bottom are sometimes found in the stomachs of all four species. This tendency to omnivorous habits gives an appearance of complexity to the accompanying food-chain diagram. A prominent feature concerning the fish is their infestation by parasitic nematodes. Nearly every specimen of *Tilapia* contained large nematodes in its gullet or stomach, a number of the *Barbus* were similarly afflicted and nematode cysts in *Clarias* were also common. All the fish have an unpleasant muddy flavour in accordance with the character of the lake water, which is not pleasant to drink.

Crocodiles are very abundant round the shore, and take an important place in the lake's ecology. They appear to feed principally on fish, and so to some extent take the place of large predator fish, such as *Lates*, in Lake Rudolf. Of fish-eating birds—darters, cormorants, fish-eagles and pelicans occur. The Goliath Heron, too, was particularly abundant, and was found nesting on the islets during December. The Njemps native fishermen use primitive methods of rod-fishing for *Tilapia* in shallow water and of spearing for *Clarias*. They do not tap the large supplies of *Tilapia* and *Barbus* in the open water.

The scheme for the presentation of data for each species in Lake Baringo is the same as for Lake Rudolf, see p. 366.

CYPRINIDAE.

LABEO CYLINDRICUS Peters. Livuli.

Distribution.—Abyssinia, East Africa to the Zambesi, Lakes Tanganyika and Nyasa.

4 specimens from L. Baringo in B.M., col. Sir H. H. Johnston. 2 specimens col. Cambs. Exp.

Habitat.—Relatively few specimens of this fish were taken, but it seems to be sparingly distributed all over the lake. It was found in the River Tiggeri at Marigat, in the swamp at the south end of the lake, along the rocky west shore and a single specimen was caught in the trawl in the open water.

Size.—34 measured specimens gave a range of lengths from 11 to 17 cm., with an average of 13.3 cm.

Food.—A bottom-feeder. 5 stomachs were examined and found to contain mud, sand, algae and a few small Crustacea.

BARBUS GREGORII Blgr. Barbel. Libile.

Distribution.—East Africa from the Upper Tana and Upper Hawash Rivers to the Rift Valley Basin.

Some specimens from Lake Baringo had been identified previously as *Barbus bynni*, see Worthington (1932 *b*, p. 124), where the species is redescribed.

3 specimens from L. Baringo, col. J. W. Gregory. 10 col. Sir H. H. Johnston. 37 col. Cambs. Exp.

Habitat.—*Barbus* appears to be very abundant all over the lake. The young were mainly restricted to the shore, though a few specimens were caught in

the trawl in the open water. Young fish were also found in the River Tiggeri at Marigat.

Size.—119 measured specimens gave a range of lengths from 19 to 68 cm., with an average of 31.9 cm.

Food.—10 stomachs of fairly large fish were examined. 1 was empty and the rest contained remains of fish, mainly *Tilapia*. A few pieces of weed were also found in one stomach. A stomach of a small fish 24 cm. long contained phytoplankton, mainly *Microcystis* and *Botryococcus*, rotifers and a few chironomid larvae.

Breeding.—The gonads of 35 fish were examined. Females outnumbered males by 17 to 5, and were considerably larger than males. The range of length for 12 breeding females was from 19 to 63 cm., with an average of 46 cm., while the range for 5 breeding males was from 20 to 47 cm., with an average of 39 cm. Breeding appears to take place at an early age in this species when the fish are quite small, for specimens of only 20 cm. had developing gonads.

CLARIIDAE.

CLARIAS MOSSAMBICUS Peters. Cat-fish. Singre. Mumi.

Distribution.—East Africa, from Abyssinia and Lake Victoria to Lake Tanganyika and the Zambesi.

1 specimen in B.M., (formerly identified as *C. lazera*), col. Jackson. 15 col. Cambs. Exp.

Systematic note.—One small specimen of *Clarias*, 15 cm. long, collected from Lake Baringo by Sir F. J. Jackson, was already in the Museum before 1931. It had been identified by Dr. Regan as *C. lazera* because the band of vomerine teeth was just more than one and a half times as wide as the premaxillary band (this value varies between 1 and $1\frac{1}{2}$ in *C. mossambicus* and $1\frac{1}{2}$ and 2 in *C. lazera*). A series of 15 specimens ranging in length from 14 to 39 cm. were preserved in 1931. In all cases the width of their vomerine bands varies from 1 to $1\frac{1}{2}$ times that of the premaxillary bands, suggesting that they are *C. mossambicus* rather than *C. lazera*. In all other respects, however, the new specimens cannot be distinguished from Jackson's fish, and in view of the variability of the species of *Clarias*, it is certain that all the Lake Baringo specimens should be regarded as the same species.

It has been previously pointed out by Worthington (1933, p. 307) that *C. lazera* and *C. mossambicus* form part of a series of species, including also *C. gariepinus* and *C. capensis*, which have definite but overlapping distributions. *C. lazera* is the most northern of the series, with a distribution extending as far south as Lake Albert and Lake Rudolf, while *C. mossambicus* is characteristic of Lake Victoria and the East African rivers. The species present in Lake Baringo is structurally intermediate between the two, though the majority of the specimens come closer to *C. mossambicus*. For this reason and because Lake Baringo falls more naturally into the distribution range of this species, it is thought best to identify the L. Baringo form with *C. mossambicus*.

Habitat.—*Clarias* seems to occur all over the lake, and specimens were taken from near every kind of shore and also from the River Tiggeri at Marigat. During flood-times large numbers come into the shallows, where they are speared by native fishermen.

Size.—The total range of lengths was from 14 to 69 cm. 8 adult specimens ranged in length from 39 to 69 cm. and gave an average of 55.5 cm.

Food.—13 stomachs were examined. 6 were empty, 6 contained pieces of weed, bundles of *Melosira*, chironomid larvae, insect-remains, sand, mud and general debris and one contained scales of *Barbus*.

Breeding.—No data, as all the fish examined were quiet.

CICHLIDAE.

TILAPIA NILOTICA (Linn.). 'Carp.' Sibore or Sopore.

Distribution.—Nile system below the Murchison Falls, including Lake Albert, Syria, Lake Tanganyika and the Upper Congo, the Chad Basin, the Senegal, Niger and certain of the East African rivers.

20 specimens from L. Baringo col. Cambs. Exp. in B.M.

Habitat.—This is the most abundant fish of the lake. It lives in shoals in the open water and visits the inshore reed areas principally for breeding. 253 specimens were taken.

Size.—The range of length was from 9 to 36 cm., with an average of 20.4 cm.

Food.—9 stomachs were all found to contain phytoplankton, mostly *Microcystis* and *Botryococcus*, rotifers and a few remains of Cladocera. In some there were also remains of *Diatomus* and brown mud.

N.B.—In all small and most large specimens large parasitic nematodes were found just inside the gullet.

Breeding.—In all gill-net catches the adults were outnumbered by young immature fish in the proportion of about 3 to 1. The males outnumbered the females by 50 to 16, and also tended to be slightly larger in size. The range of length of 17 breeding males was from 26 to 36 cm., with an average of 31.6 cm., while the range for 4 breeding females was from 26 to 33 cm., with an average of 29.8 cm. Young fish from 9 cm. long were very abundant in the open water and smaller fry swarmed in shoals all round the edge of the lake.

The adults visit the inshore sandy water of about 2 to 4 feet in depth for the purpose of breeding. Like other African Cichlidae, the male scours out a hollow in the sand where the female lays her eggs. After fertilization the female guards the eggs and the developing fry in her mouth.

LAKE HANNINGTON.

Lake Hannington is another small rift lake about 4 miles long and a quarter to half a mile wide, lying about 10 miles to the south of Lake Baringo. There is no doubt that at one time the two lakes were connected. The northern part is only a few feet deep; the southern part has not been sounded.

The lake is supplied with water at the north end by a comparatively fresh stream (0.0064 Normal). Owing to an accumulation of the salts from the stream and the fact that there is no outlet, the water of the lake itself has become extremely alkaline (0.16 N.). As a result, there is very little life in the lake, with the exception of vast quantities of blue-green algae (*Arthrospira*), which supply food for huge flocks of flamingoes. No fish were caught, and the natives say that there are none in the lake. *Clarias mossambicus* and a *Labeo cylindricus*, however, were taken from the affluent stream. Stomach-contents showed that the *Clarias* had been eating fish, pieces of weed and phytoplankton, while the *Labeo* had been feeding on phytoplankton and sand. Crocodiles abound in the stream, and occur also in the lake, in spite of the absence of fish.

SUMMARY.

In view of the growing importance of fish for native consumption, the resources of the African lakes are sure to be exploited in the near future, but it is essential to have a sound understanding of the fish and other fauna and flora in each lake before exploitation is started. This paper places on record the available data for Lake Rudolf and Lake Baringo, on which no previous ecological work had been attempted.

Lake Rudolf is characterized by a high temperature and very alkaline water, and contains a variety of environments inhabited by different fish-associations. The fauna has pronounced nilotic affinities, except that there is only one member of the family Mormyridae. Several species, however, have come to differ from their nilotic ancestors, and the comparison of the fauna with that of other waters can be used as evidence for past changes in the drainage systems of East Africa.

The fish fauna of Lake Rudolf is roughly divisible into three main associations of species—one in the inshore waters, one in the open water, and one near the bottom. From data supplied by large numbers of stomach examinations, the food-chains for each of these habitats can be reconstructed.

Lake Baringo is less warm, the water has a relatively low alkalinity, and is uniformly shallow and muddy. The fish fauna consists of few species, and shows affinities with that of the East African rivers which flow to the Indian Ocean.

Owing to the shallowness of Lake Baringo, there is no differentiation into species-associations, and the food-chains are complicated by the presence of food from the bottom in all the species of fish.

The bulk of this paper contains analyses of field-observations on the size, feeding and breeding habits of each of the species found in the lakes.

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The Arctic Plankton collected by the *Nautilus* Expedition, 1931. Parts I-III.

Part I.—General Account. By Prof. A. C. HARDY.

Part II.—Report on the Copepoda. By G. P. FARRAN.

Part III.—Report on the Appendicularians. By Prof. W. GARSTANG
and Dr. E. GEORGESON.

(With 2 Text-figures)

[Read 30 January 1936.]

PART I.—GENERAL ACCOUNT. By Prof. A. C. HARDY, M.A.,
Department of Zoology and Oceanography, University College, Hull.

INTRODUCTION.

During the voyage of the submarine *Nautilus*, under the leadership of Sir Hubert Wilkins, ten samples of plankton were collected by Dr. H. U. Sverdrup, leader of the scientific staff, at five stations to the north of Spitzbergen between August 30 and September 5, 1931. The collection, whilst small, is of particular interest in that it appears to include the most northerly 'open water' plankton samples we possess, lying between $81^{\circ} 01' N.$ and $81^{\circ} 50' N.*$ Sverdrup (1933) in his account of the expedition writes as follows:—

'On account of many delays the plan of crossing the Polar Sea had to be abandoned because of the advanced season, and when we finally left Advent Bay, Spitsbergen, on August 18, we could at best hope to obtain a single oceanographic section between Spitsbergen and a point perhaps two hundred miles further to the north. Even this hope failed because of the loss of the diving rudder, but thanks to extraordinarily favorable ice conditions we reached in open water a higher latitude than any earlier expedition starting out from Spitsbergen by ship. Prior to 1931 the highest latitude, $81^{\circ} 43'$, had been reached in 1868 by A. E. Nordenskiöld on board *Sofia*, while our most northern observation gave a latitude of $81^{\circ} 59'$, and it is of still greater interest to note that we were to the north of $81^{\circ} 50'$ between longitudes 12 E. and 20 E., in which region very few ships previously have passed the parallel of 81° and from which no oceanographic data are available. Thanks to these favorable circumstances we were able to obtain a series of observations which throw light on some of the problems relating to the currents in the Polar Sea.'

Further, the method of collection marks an interesting innovation in oceanographical technique. The samples were collected by means of closing nets lowered through a special hatchway in the bottom of the submarine from a winch operated in a pressure chamber.

* Nansen, when iced-in and drifting on his great voyage in the *Fram*, 1893-6, collected seventeen plankton samples through openings in the ice from $78^{\circ} 13' N.$ to $84^{\circ} 40' N.$ —only two of these lay north of $81^{\circ} 50' N.$ (Gran, 1904).

Dr. Sverdrup invited me to examine and report upon the collection. I am indebted to a number of specialists who kindly undertook to assist me in the identification of certain groups as follows:—Dr. S. T. Burfield, Liverpool University (the Chaetognatha); Mr. G. P. Farran, Irish Free State Fishery Department (the Copepoda); Professor W. Garstang and Dr. E. Georgeson, Leeds University (the Appendicularia); Dr. Marie Lebour, the Plymouth Laboratory (the Dinoflagellates); Capt. A. K. Totton, British Museum (Natural History) (the Siphonophora). For the remaining identifications I have been responsible.

I have persuaded Mr. Farran, and Professor Garstang and Dr. Georgeson, to allow their reports to appear as separate parts immediately following the present general account of the plankton. They are Parts II and III respectively.

BRIEF DESCRIPTION OF THE EXPEDITION.

Sverdrup (1933) gives a full account of the aims and equipment of the expedition and the physical oceanography accomplished. 'One of the principal objects of the expedition', he writes, 'was to obtain exact observations from the deep parts of the Polar Sea because of the importance of such data for the understanding of the currents and properties of the waters of the Polar Sea'.

For the first time a submarine was employed for oceanographic or polar research; it was a daring enterprise planned with a bold imagination. Owing to the unexpected delays in the preparation of the ship and her unfortunate breakdown on the way to Europe, the start was made so late in the season that no more than preliminary trials could be hoped for. The submarine, which was an old one, proved unequal to the task; but the method of carrying out research from the pressure chamber in the bottom of the ship was fully justified. Core samples from the ocean floor were obtained from depths ranging from 735 to 3,660 m. Water samples were obtained from depths down to 3,000 m., and vertical plankton hauls made from depths ranging to 250 m.

The following extracts from Dr. Sverdrup's report will indicate the difficulties under which the expedition worked:—

'We left Advent Bay in Spitsbergen on August 18 and on the 19th the northern coast of Spitsbergen disappeared on the southern horizon. We had two tasks before us: In the first place to test whether the submarine could navigate safely under the ice, whether the lanes and openings in the ice could be seen from underneath, and whether the submarine could reach the surface in such openings. In the second place, we had to learn whether our scientific programme could be carried out under the unfavorable conditions on board a submarine, and especially if the oceanographic work could be undertaken from the diving compartment.

'The loss of the diving rudder which was discovered on August 22 made diving and travel under the ice impossible and, therefore, it remained to try out the scientific equipment and make such observations as conditions would permit. . . .

'A long-lasting storm from the east pressed the ice together and closed every opening;

for days we had to wait outside of the pack-ice, hoping that the wind would fall, or change direction and that the ice-fields would open up. The storm, however, had not only packed the ice together, but had carried it towards the north and by following the boundary of the pack-ice we, therefore, reached a higher latitude than any other expedition vessel starting out from Spitsbergen, and could undertake our observations in unexplored regions.

During the night between August 25 and 26 the wind finally changed from E. to SSW. On the morning of the 26th a gentle breeze from SSW. was blowing and the swell was rapidly decreasing. A number (99) of soundings had been taken before August 26 by means of the sonic depth-finder under the supervision of Mr. Soule and rhythmic time signals for checking the rate of the chronometers of the gravity apparatus had been received twice daily by Dr. Villinger. Apart from this, no scientific observations had been carried out, except for a few meteorological observations which on account of their unsystematic and accidental character are of no value. The 11 days from August 26 to September 6 were, on the other hand, mainly devoted to scientific work.

Ten stations were worked in these eleven days and a remarkable programme of oceanographical work was carried through. The positions of the stations

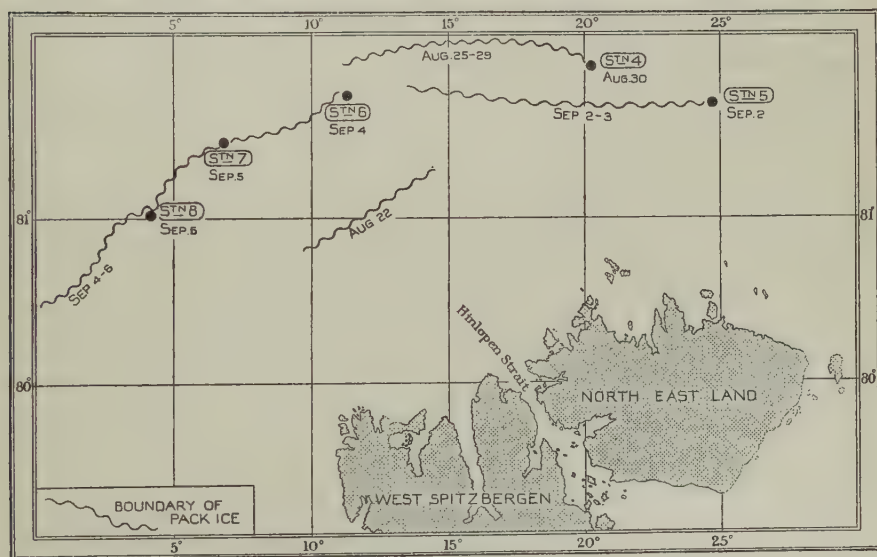


FIG. 1.—Showing the positions of the *Nautilus* stations 4 to 8 at which plankton samples were obtained and also the boundary of the pack-ice on different dates (from Sverdrup).

4 to 8 at which plankton samples were taken are shown, together with the shifting boundary of pack-ice, in fig. 1.

Oceanography will owe a debt of gratitude to Sir Hubert Wilkins and Dr. Sverdrup, not only for the results obtained on this pioneer attempt,

but because in time other attempts will be made to explore the under-ice conditions in high latitudes, building on the experience of the *Nautilus**.

It will be of interest further to include Dr. Sverdrup's account of the ice conditions in the area in which the plankton samples were taken. It is as follows :—

'The first ice was met with on August 19, in latitude $80^{\circ} 20' N.$ and longitude $12^{\circ} E.$ The ice was scattered but soon became so dense that further progress of the vessel was prevented. It is very probable that this ice represented an isolated belt because water sky could be seen to the northeast and on August 20, when a strong E-wind was blowing, a swell from the east was perceptible.

'During the night between the 20th and the 21st, the ice evidently was carried more to the north than was the vessel, because no ice was in sight when it cleared up in the evening of the 21st. Steering NE. the ice was again met with in $80^{\circ} 46' N.$ and $10^{\circ} 30' E.$ During the 22nd we had the ice in sight on the port side from the early morning until the afternoon, when progress towards the northeast was stopped by ice in $81^{\circ} 24' N.$ and $14^{\circ} 20' E.$ During the following days the ice again was carried much more to the north than the vessel, which was drifting before a fresh E-wind. When progress was resumed on the 25th we reached $81^{\circ} 53' N.$ and $11^{\circ} 15' E.$ before meeting the ice. Here we found the pack-ice jammed tightly together and the edge running approximately east-west.

'On August 25 to August 29 we followed the edge of the pack-ice in latitude about $81^{\circ} 55' N.$ and between longitudes $11^{\circ} 15' E.$ and $21^{\circ} 30' E.$ During these days the ice remained tightly packed under the influence of a weak east wind. The wind changed to northerly on August 30, and the ice loosened up. At the same time the edge moved towards the south and was in latitude $81^{\circ} 40' N.$ on the evening of September 1. During the night between September 1 and 2 we followed the ice in the general direction of E. by S. and on the 2nd we pushed about 8 miles into the pack, reaching a latitude $81^{\circ} 38' N.$ in longitude $24^{\circ} 45' E.$

'In the night between September 2 and 3, the border of the ice was running practically as a straight line between $81^{\circ} 30' N., 24^{\circ} 30' E.$ and $81^{\circ} 44' N., 11^{\circ} 15' E.$ At the latter position the edge bent towards the southwest.

'On September 4, 5, and 6, we followed the ice in the general direction of southwest, between the last named position and $80^{\circ} 10' N., 1^{\circ} 20' W.'$

I must make one further quotation from Dr. Sverdrup's report :—

'In this place I wish to emphasize that our scientific work could not have been accomplished without the unfailing interest of Sir Hubert Wilkins and the invaluable help of the officers and crew of the *Nautilus*.

'The interest which Wilkins himself took in the scientific work is illustrated by the fact that on the day when the loss of the diving rudder was discovered and we actually were lying in the ice with a disabled submarine, he had no thought of returning to safety before we had tested our scientific equipment under conditions which were worse than those to be expected on a journey partly under the ice. I can, I believe, safely state that on August 22 every one on board except Wilkins would have been willing to return, acknowledging a complete defeat, but he did not for one moment consider the possibility of returning before every opportunity for scientific work had been taken. He, therefore, deserves full credit for what has been accomplished.'

* Since this was written Sir Hubert Wilkins has announced his intention of leading a second submarine expedition to the north polar regions.

DETAILS OF SAMPLES TAKEN.

Dr. Sverdrup in sending me the collection writes as follows :—

‘The samples were all collected by means of closing nets, all except one with nets made by means of Swiss silk No. 25 and with an opening of 40 cm. (diameter of top part). The one exception was taken with net of silk No. 10 and an opening of 60 cm.’

Silk No. 25 has approximately 200 meshes to the inch, and No. 10 approximately 113 to the inch.

The details regarding the samples may be tabulated as follows :—

Sample No.	Station.	Date.	Position.	Depth.	Silk.
1	4	30. viii. 31	81° 50' N., 20° 15' E.	Surface.	25 { (Net drag-
2	4	30. viii. 31	81° 50' N., 20° 15' E.	100-50	25 { ging 1 min.).
3	4	30. viii. 31	81° 50' N., 20° 15' E.	50-0	25
4	4	30. viii. 31	81° 50' N., 20° 15' E.	250-100	10
5	5	2. ix. 31	81° 38' N., 24° 45' E.	100-50	25
6	5	2. ix. 31	81° 38' N., 24° 45' E.	50-5	25
7	6	4. ix. 31	81° 40' N., 11° 20' E.	100-50	25
8	6	4. ix. 31	81° 40' N., 11° 20' E.	50-5	25
9	7	5. ix. 31	81° 24' N., 6° 50' E.	50-5	25
10	8	5. ix. 31	81° 01' N., 4° 15' E.	30-5	25 { (50 m. wire hauled in).

METHOD OF EXAMINATION.

All the plankton animals other than Protozoa and Copepoda were picked out individually, and either identified at once or sent to the various experts for examination. In regard to Protozoa and phytoplankton the samples were first of all examined for rarer forms and then estimates of the numbers of the more abundant forms made by Stempel pipette methods. The Copepoda, if numerous, were sent with the samples to Mr. Farran, otherwise they were picked out individually. Samples containing Dinoflagellates were separated from the Copepoda and sent to Dr. Lebour.

DESCRIPTION OF THE PLANKTON.

The scarcity of the larger planktonic animals in the collection is no doubt due to all the samples but one being taken with nets of very fine mesh silk (200 meshes to the inch). The one haul with a coarser mesh net (113 meshes to the inch) was from 250-100 m. at St. 4. The collection, therefore, must be regarded as giving only a knowledge of the smaller forms of planktonic life; but it is nevertheless of great interest in that it shows the conditions of this life—including the phytoplankton—in the late summer along the edge of the pack-ice in higher latitudes than have been sampled before. The same type of net was used in the top 50 m. at each of the five stations which lie along a front extending for some 200 miles, and at three of these stations hauls with

the same net were made down to 100 m. Thus whilst the number of samples are not many, and for this reason prevent us from making close correlations between the details of plankton distribution and those of hydrology, the set of five stations is sufficient to give us a good indication of the general conditions

TABLE I.—*Hydrological data at plankton stations.*

Station.	Sound- ing (m.).	Depth of observa- tion (m.).	T (° C.).	S (%).	σ_t .	O ₂ (ml/L)	O (%).	pH.	P ₂ O ₅ (mg./m. ³).	NO (mg./m. ³).
No. 4	3500	10	-1.61	31.58	25.42	8.78	103	8.37	32	0.0
		25	-1.53	33.65	27.10	9.16	109	.30	48	0.0
		50	-1.71	34.10	.46	7.66	91	.18	59	0.0
		75	-0.79	.37	.66	7.38	90	.17	67	0.0
		100	-0.40	.42	.67	7.36	91	.19	67	0.0
No. 5	560	10	2.41	33.39	26.67	7.01	92	8.32	29	0.0
		25	3.22	34.04	27.12	.28	98	.32	32	0.0
		50	..	.75	.69	6.95	94	.24	61	1.8
		75	2.87	.86	.80	.84	92	.20	67	0.8
		100	3.15	.95	.85	.67	91	.22	67	0.0
		150	3.43	35.02	.88	.70	92	.22	71	0.0
		200	3.16	.03	.91	.99	95	.19	73	0.0
No. 6	1690	5	-0.62	31.22	25.10	..	..	..	..	..
		25	+0.60	33.99	27.28	8.77	111	8.28	45	..
		50	-0.21	34.42	.66	7.42	92	.13	64	..
		100	1.48	.76	.84	6.98	91	.08	77	..
No. 7	760	5	-0.51	..	..	..	..	..	..	..
		25	0.27	33.69	27.05	8.44	105	8.31	28	0.0
		50	0.68	34.49	.67	7.01	89	.20	51	2.9
		75	1.00	.64	.78	.11	91	.17	63	4.2
		100	2.48	.93	.90	6.61	88	.14	72	0.0
No. 8	740	5	-0.95	..	..	..	..	..	..	..
		25	-1.51	33.70	27.14	8.45	101	8.24	36	0.0
		50	0.29	34.38	.61	7.13	90	.19	50	1.4
		75	0.90	.61	.77	6.90	88	.13	58	0.0
		100	2.71	.94	.89	6.76	91	.09	68	0.0

of the phytoplankton and the smaller zooplankton. The value of the details of the records in conjunction with those of hydrology will be increased when they may be compared with such records of later expeditions in these high latitudes. The hydrological details are given in Table I and the actual or estimated numbers of the different organisms present are given in Table II.

PHYTOPLANKTON.

The phytoplankton was not rich in species, there being only thirteen species of diatom, eight species of dinoflagellates, and one species of colonial flagellate. The estimated numbers of diatoms in the samples from the top 50 m. at Sts. 4, 6, 7, and 8 were 880,400, 282,500, 567,500, and 460,000 respectively, but at the most easterly station, St. 5, it is remarkable that no diatoms at all were taken in the top 50 m. A small number at this station were taken from 50–100 m. Not only were the Stempel pipette samples void of them, but extensive searching in the whole sample revealed a complete absence of phytoplankton. There can be no question of the net not having fished properly, because of the presence of zooplankton forms in the haul, Tintinnids and Copepod nauplii, together with large numbers of adult copepoda. The highest numbers of the copepods *Calanus finmarchicus* and *Pseudocalanus elongatus* were taken at this station. Nansen's 1893–6 samples taken in the pack-ice contained very little phytoplankton, although it must be noted that none was taken between June 22 and October 12 (his seventeen samples were spread in time as follows: February (1), March (3), April (6), May (2), June (1), and October (4) *). Gran (1903), commenting on the paucity of phytoplankton, writes: 'All the plankton samples taken later in the expedition contain only a few specimens of algae, while at the same time there is quite an abundant animal life. . . . It is difficult to understand how all the crustaceans (*Calanus finmarchicus* &c.) that swarm in the upper strata of the Polar Sea can find the means of sustaining life; I did not succeed in finding any trace of diatoms in their intestinal canal and the plankton contained very little of their excrements'. Referring to this *Nautilus* St. 5, Sverdrup (1933) writes: 'This station was taken when surrounded by ice, but in spite of this we found a temperature of 2°·41 C. at a depth of 10 m., and this high temperature must be ascribed to a flow of warm water from the south'. The temperatures at the more westerly stations 4, 6, 7, and 8 at 5 or 10 m. were: —1°·61 C., —0°·62 C., —0°·51 C., and —0°·95 C. respectively. Correlated with the lack of phytoplankton at St. 5 we find here the oxygen content of the upper layers considerably lower than at other stations. It is noteworthy that the available phosphates at this station were by no means used up, so that diatom production at this station was not limited by this factor; however, the phosphate in the upper layers was less than in lower layers, suggesting that there had been a considerable production of phytoplankton in this body of water at some time earlier in the season further south. The gradient in phosphate values increasing from the surface downwards seen at all stations is comparable with the conditions found in September by Kreps and Verjinskaya (1930) in the Barents Sea between latitudes 69° and 79° N., only their upper layer values were approximately half those recorded by the *Nautilus*. The higher phosphate values remaining towards the end of the

* The numbers here refer to the number of samples taken in each month, not to the days of the month.

TABLE II.—Estimated or actual numbers of plankton organisms other than Copepoda* at stations arranged in geographical order from west to east. (Actual numbers in heavy type.)

Station.....	No. 8.	No. 7.		No. 6.		No. 4.		No. 5.	
		50-5.		50-5.	100-50.	Surface.	50-0.	100-50.	50-5.
Depth in metres	30-5.								100-50.
DIATOMALES.									
<i>Thalassiosira gravida</i>	4,800	400		..	..	..	..	..	..
<i>Lauderia glacialis</i> .....	..	200		..	..	..	..	..	..
<i>Rhizosolenia styliformis</i> .....	..	..		..	120	..	..	..	..
<i>Rh. hebetata</i> f. <i>semispina</i>	129,600	185,200		2,000	120	..	365,340	1,200	240
<i>Rh. hebetata</i> f. <i>hiemalis</i> .....	..	..		100	..	..	..	..	..
<i>Chaetoceros altanicus</i>	1,200	700		1,500	840	..	2,280	600	..
<i>Ch. janischianus</i>	4,080	3,200		..	..	..	..	..	..
<i>Ch. densus</i> .....	..	1,400		..	..	2,000	32,560	..	240
<i>Ch. borealis</i>	9,600	600		1,000	240	500	..	..	..
<i>Ch. convolutus</i>	8,400	9,100		1,200	1,680	2,000	73,700	1,600	240
<i>Ch. decipiens</i>	302,400	355,600		273,000	13,920	6,100	406,280	3,400	4,200
<i>Ch. mitra</i> .....	..	1,000		..	..	..	..	..	..
<i>Ch. teres</i> .....	..	10,100		3,700	..	..	..	..	..
<i>Fragillaria oceanica</i> .....	..	..		..	..	..	240	..	..
DINOFLLAGELLATA									
<i>Phalacroma rotundatum</i>	F	G		F	IT	..	F	..	..
<i>Dinophysis acuminata</i> .....	..	..		F	..	..	..	..	..
<i>Peridinium depressum</i>	F	F		IT	IT	..	F	..	..
<i>P. islandicum</i> ?	F	..		F	F	..	..	..	..
<i>P. pallidum</i>	CG	CG		F	..	..	..	..	..
<i>P. pallidum</i>	CG	F		F	..	..	..	..	..

[illegible]

* The Copepoda are tabulated in Part II.

+ This haul was taken with a wider mesh net, see p. 395.

summer season when compared with those at lower latitudes, whilst not so high as those in the Antarctic, lead one to suppose that in the far north, as in the far south, lack of phosphates does not constitute a limiting factor in phytoplankton production.

All the diatoms have been recorded before as typical of the Arctic seas (Cleve, 1873, 1883, 1899, 1900; Gran, 1902, 1905; Meunier, 1910; Lebour, 1930). The genus *Chaetoceros* predominated in the phytoplankton, being represented by eight species. *Ch. decipiens* Cleve was the most abundant species, being taken in large numbers in the top 50 m. at all the four westerly stations. The next most abundant diatom was *Rhizosolenia hebatata* f. *semispina* (Hensen). These two species together with *Chaetoceros convolutus* Castr. were taken at all stations. *Ch. atlanticus* Cleve and *Ch. borealis* Bailey were present at all stations except St. 5. *Ch. densus* Cleve was present in moderate numbers at St. 4 and small numbers at 5 and 7. *Thalassiosira graviora* Cleve, *Lauderia glacialis* (Grun), *Rhizosolenia styliiformis* Brightw., *Rh. hebatata* f. *hiemalis* Gran, *Chaetoceros janischianus* Castr., *Ch. mitra* (Bailey), and *Ch. teres* Cleve were present at one or more of the three western stations but never abundant. A few specimens of *Fragilaria oceanica* Cleve were taken at St. 4. Nansen's plankton samples proper (i.e. apart from the samples of diatoms taken from the surface of ice-floes which included many neritic species) contained only the following species (Gran, 1903):—*Chaetoceros socialis* abundant at three stations, *Ch. decipiens* rather common at the same three stations, and *Ch. contortum*, *Ch. criophilum*, *Coscinodiscus oculus iridis* Ehr., and *Fragilaria oceanica* only recorded as rare. In ten of the samples, February 21 to May 1, no traces of diatoms could be found.

Römer and Schaudinn's *Helgoland* Expedition of 1898 obtained in the Spitzbergen region the following oceanic diatoms (Gran, 1904) out of nine stations: *Coscinodiscus oculus iridis* at three stations, *Rhizosolenia semispina* at four stations, *Rh. obtusa* at one station, *Chaetoceros convolutus* at two stations, *Ch. borealis* at three stations, *Ch. decipiens* at five stations, and *Nitzschia serriata* at one station.

Regarding the Dinoflagellates, which were only abundant at the two western stations 7 and 8, and absent from the most easterly St. 5, Dr. Lebour writes: 'All are well known and what one would expect to get near Spitzbergen and in the Greenland Seas'. The only species which were present in large numbers were *Peridinium pallidum* Ostensfeld and *P. pellucidum* (Bergh) Schütt. *Phalacroma rotundatum* (Clap. & Lach.) was taken in fair numbers at St. 7. The remainder *Dinophysis accuminata* (Clap. & Lach.), *Peridinium depressum* Bailey, *P. islandicum*? Paulsen, *Ceratium arcticum* (Ehrenberg) Cleve, and *C. tripos* O. K. Müller were rare or very rare.

Colonies of the flagellate *Dinobryon pellucidum* Levander (= *D. balticum* Schütt) were present at St. 8. It has been recorded for the Arctic seas by Cleve (1900), Broch (1909), Meunier (1910), and others,

ZOOPLANKTON.

The protozoa were represented by the Tintinnidae, which formed a prominent feature of the collection. There were eight species present, all of which had been taken in the Arctic before.

The following in the *Nautilus* collection had been taken by Brandt (1896) in the Davis Strait :—

Cyrtarocyclus gigantea Brandt.

C. media Brandt (= *C. denticulata* var. *media* Brandt).

C. edentata Brandt.

Ptychocyclus drygalski Brandt.

Amphorella norvegica Dad. (= *Tintinnus gracilis* Brandt).

Tintinnus acuminiatum (Clap. & Lach.) (= *T. secatus* Brandt).

Meunier (1910) for the Barents Sea also records these species, but in addition the following were taken in the *Nautilus* collection :—

Cyrtarocyclus cuspidate Meunier.

C. hemifusus Meunier.

The Tintinnids, like the diatoms, were most abundant at the western stations. *Ptychocyclus drygalski* occurred in the largest numbers, and next in importance came *Cyrtarocyclus gigantea* and *C. denticulata* var. *media*. *Tintinnus acuminiatum* was only present at St. 5 and in small numbers.

Only a single medusa, *Aglantha digitale* Haeckel, was taken at St. 4, 250–100 m. ; although widely spread in lower latitudes this species has been taken by a number of expeditions in the north and is regarded by Mayer (1910) as a typically Arctic species. A siphonophore was taken in the same sample (the wider mesh net). This was sent to Captain A. K. Totton, who writes, ' There is no doubt in my mind that it is the anterior nectophore of a specimen of *Dimophyes arctica*. It is a somewhat squashed specimen, but I have seen many others similarly distorted '.

The Ctenophora were represented by four specimens of *Mertensia ovum* Lesson, which is well known from the Arctic (Mayer, 1912). Three were taken in the warmer water, 0–50 m., of the easterly St. 5, and one in the colder water, 0–50 m., of St. 7.

The twenty-four specimens of Chaetognatha in the collection were examined by Dr. S. T. Burfield, who found two species to be present, viz. : *Sagitta elegans* (arctica) Aur. and *Eukrohnia hamata* (Mob.). He writes : ' These are already known as Arctic forms. A third Arctic species *S. maxima* (Conant) was not present. All the specimens in the collection were small and immature. Although the catches were made at varying depths the small numbers of hauls and species make it impossible to draw any conclusions as to distribution '. The numbers at the different stations are shown in Table II (p. 399).

The Copepoda are reported upon in detail by Mr. G. P. Farran in Part II of this report.

Only a single Amphipod, *Parathemisto gaudichaudi* (Guérin), was taken at St. 6.

Whilst, as already remarked, it is not surprising that very few macroplankton specimens were taken in the samples on account of the fine mesh nets used, it is perhaps remarkable that no larval stages of Euphausiacea were met with.

The pteropoda were represented by a number of young *Limacina helicina* (Phipps) which were present at all stations in 0–50 m. except St. 7.

Specimens of the Appendicularian *Oikopleura vanhoeffeni* Lohmann are separately reported on by Prof. W. Garstang and Dr. E. Georgeson in Part III of the report.

This completes the collection.

The samples are characteristically polar, a small number of species being represented. They have very much the same general character as the August and September samples obtained in somewhat lower latitudes by the Swedish Expeditions to Spitzbergen in 1898 (Cleve, 1899, and Aurivillius, 1899) and to Greenland in 1899 (Cleve, 1900), at the northern oceanic stations by the Duke of Orleans's Expedition of 1907 to the Barents Sea (Meunier, 1910), and again by the Swedish Expedition to Spitzbergen in 1908 (Broch, 1909).

The importance of the *Nautilus* collection lies in the extension of our knowledge of this Arctic plankton into higher latitudes.

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PART II.—REPORT ON THE COPEPODA.

By G. P. FARRAN.

The collection of Copepoda here described was made during the voyage of the submarine *Nautilus* about 80 miles north of Spitzbergen, ten samples being taken at five stations situated in an area measuring about 180 miles from east to west and 50 miles from north to south. The samples were submitted to me through the good offices of Professor A. C. Hardy. Particulars of the samples are given in Part I, p. 391.

Sixteen species were met with. Thirteen of them are already known from polar regions, one of them, *Ectinosoma finmarchicum*, belonging to a genus which is not usually a constituent of the open-sea plankton. The remainder, viz. *Temora longicornis*, *Microcalanus pusillus*, and *Metridia lucens*, are common Atlantic forms which do not appear to have been previously recorded from such high latitudes.

List of species and numbers of specimens per sample. Stations arranged in geographical order from west to east.

Station	No. 8.	No. 7.	No. 6.		No. 4.				No. 5.	
Depth in metres	30-5	50-5.	50-5.	100-50.	0.	50-0.	100-50.	200-100.	50-5.	100-50.
Sample number	10.	9.	8.	7.	1	3.	2.	4.	5.	6.
1. <i>Calanus finmarchicus</i>	20	30	430	156	18	442	83	220	74	1,000
2. <i>C. hyperboreus</i> .....	..	16	6	1	..	9	3	3	..	..
3. <i>Pseudocalanus elongatus</i> ..	95	60	102	13	..	145	22	10	2	240
4. <i>Microcalanus pusillus</i>.....	..	..	..	10	..	25	225	610	22	24
5. <i>M. pygmaeus</i> .....	..	..	..	..	..	..	1	1	..	0
6. <i>Euchaeta</i> sp. juv. ....	..	..	..	1	..	..	5	2	1	..
7. <i>Scolecithricella minor</i> .....	..	1	..	..	..	..	2	4	..	3
8. <i>Temora longicornis</i> .....	..	..	..	..	..	..	2	..	..	..
9. <i>Metridia lucens</i> .....	..	..	..	1	..	..	..	..	..	..
10. <i>M. longa</i> .....	..	..	..	1	..	..	..	8	1	..
11. <i>Acartia longiremis</i> .....	..	1	..	1	10	..	..	..	..	..
12. <i>Oithona similis</i>	2,760	2,800	360	270	..	750	210	234	82	1,200
13. <i>O. atlantica</i>	1	..	..	..	..	..	1	150	8	1
14. <i>Microsetella norvegica</i>	830	390	54	5	..	25	2	..	4	2
15. <i>Ectinosoma finmarchicum</i> ..	3	5	2	..	..	47	..	..	..	..
16. <i>Oncaea borealis</i>	1	..	..	90	..	110	375	320	55	30
Nauplii*, mainly Copepoda.	7,440	5,400	3,000	8,160	..	900	4,200	..	240	1,100

* The numbers for the Nauplii have been furnished by Prof. A. C. Hardy.

The details of the physical observations made at these stations are given in Part I, Table I, p. 396. There was no apparent connection between the physical conditions and the distribution of the Copepod plankton as shown by the tow-nettings.

NOTES ON SPECIES.

1. *CALANUS FINMARCHICUS* (Gunner).

Present in all samples in numbers varying from 64 to 0.5 per cent. It formed the greatest bulk of all the samples except Nos. 2, 9, and 10, which were mainly made up of abundance of very minute species. Adults were very scarce, males being absent and females in all forming less than 1 per cent. of the total numbers. The numbers at each stage of development in each sample were:—

Sample	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
♀ .....	..	4	18	13	2	6	4	..	..	..
Stage V	16	45	145	30	57	678	80	135	7	..
„ IV	2	27	184	18	15	270	64	250	12	1
„ III .....	..	6	93	2	..	42	5	40	8	1
„ II .....	..	2	20	..	..	3	3	60	3	1
„ I .....	..	..	..	..	..	..	..	..	..	3

The adult females showed a wide range in size, from 2.9 to 5.2 mm. Of 25 taken at random for measurement, nine, or 36 per cent., were between 3.25 and 3.55 mm., and the remainder distributed evenly along the rest of the range. These figures suggest the presence of a more numerous group of from 2.9 to 3.9 mm., and a scarcer one of from 4.0 to 5.2 mm. Measurement of the two preceding stages indicate a corresponding grouping, the measurement of 70 and 60 specimens of stages IV and V from Sample 8 giving the following numbers at each 0.1 mm. :—

Length (mm.) ...	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0
Stage IV	2	6	9	17	15	14	3	..	2	2	..
„ V .....	..	..	..	..	..	..	..	1	1	5	14
Length (mm.) ...	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1
Stage IV .....	..	..	..	..	..	..	..	..	..	..	=70
„ V	8	7	9	3	4	..	1	3	1	1	2 =60

Several investigators have called attention to the existence of this wide range of sizes in northern waters. In the neighbourhood of Spitzbergen, Mrazek records specimens of 3.4–5.2 mm., Damas and Koefoed 3.2–5.4 mm. and With 3.4 mm. Mrazek and With both tried without success to find a distinguishing character between the large and small forms in the denticulation of the inner margin of the first basal joint of the 5th pair of legs. Two female specimens which I examined, measuring 3.60 mm. and 5.22 mm., had each 43 denticulations on the inner margin. This is a higher number than I have found on the west coast of Ireland, where the average number is about 33.

2. *CALANUS HYPERBOREUS* Kröyer.

Only one adult, a female, was found, in sample No. 3, but in several samples small numbers of specimens in stages III to V occurred, easily distinguishable from *Calanus finmarchicus* by their greater transparency and more pointed cephalon.

3. *PSEUDOCALANUS ELONGATUS* (Boeck).

Present in small numbers in all samples except that from the surface, but in two only, Nos. 3 and 8, did they reach 10 per cent. of the total. Almost all were immature, mostly in stage V. The few adult females measured from 1.5 to 1.7 mm. and were of the slender form figured by Sars (1903) under the name of *P. gracilis*. Only one male was found. It measured 1.5 mm., which is larger than that recorded by Sars, viz. 1.1 mm. I have followed With in uniting *P. gracilis* with *P. elongatus*, as the available material was insufficient to justify any departure from his conclusions.

4. *MICROCALANUS PUSILLUS* G. O. Sars.

Only a very few adults, all females from 0.63 to 0.67 mm. in length, were found, but young stages were plentiful in samples Nos. 2 and 4 and scarce in Nos. 3, 5, and 7.

5. *MICROCALANUS PYGMAEUS* (G. O. Sars).

One female, length 0.77 mm., with antennules noticeably longer than in the specimens of *M. pusillus*, was found in sample No. 4, and one specimen in stage V, length 0.80 mm., in sample No. 2. Possibly other immature specimens were overlooked, but in any case their numbers must have been extremely small.

Sars described this species from north of the New Siberian Islands, and from published records it would seem to be the common Arctic form. I have recorded *M. pygmaeus* and *M. pusillus* under separate names to call attention to the occurrence of both forms, though With considers them to be extreme forms of one species.

6. *EUCHAETA* sp.

A few immature specimens of *Euchaeta* in stages II and III occurred in samples Nos. 2, 4, and 5. It is not possible to assign them to any species, but as both *E. norvegica* and *E. glacialis* have been recorded from Polar seas it is probable that they belong to one of these species.

7. *SCOLECITHRICELLA MINOR* (Brady).

From one to four specimens, females and immature, occurred in samples Nos. 2, 4, 6, and 9, one female in each sample. *S. romeri*, which is probably identical with *S. minor*, has been recorded by Mrazek from the Arctic, and the Duc d'Orleans's expedition found *S. minor* to be fairly common between Spitzbergen and Greenland.

8. TEMORA LONGICORNIS (Mull.).

In sample No. 2 one female, length 1.67 mm., and one specimen in stage III were found.

9. METRIDIA LONGA (Lubb.).

Found in samples No. 4, three females and five stage V, No. 5, one stage IV, and No. 7, one female. This is a common species in the polar basin.

10. METRIDIA LUCENS Boeck.

One immature female, stage V, length 1.7 mm., was found in sample No. 7. As the corresponding stage in *Metridia longa* measures 3.0 mm. there is no possibility that the specimen was a young example of that species.

M. lucens is a very abundant North Atlantic oceanic species, and the single example probably represents a specimen drifted northwards.

11. ACARTIA LONGIREMIS (Lillj.).

Ten specimens, mostly immature, were found in the surface sample No. 1, and single specimens in samples Nos. 7 and 9. It has been recorded in small numbers by Sars from the New Siberian Islands, and seems to be the ordinary Arctic species of the genus, though *A. clausi* has been recorded by Willey (1920) from north of Alaska.

12. OITHONA SIMILIS Claus.

Numerically the commonest species in the collection, most plentiful on the two most westerly stations. A few were recorded by Sars from the New Siberian Islands.

13. OITHONA ATLANTICA Farran.

? *Oithona spinirostris* Claus.

Oithona atlantica Rosendorn, 1917.

Occurred in moderate numbers in sample No. 4, 250-100 m., the deepest haul, and a few specimens were also found in samples Nos. 2, 5, and 6. Length, female, 1.32-1.44 mm. Rosendorn has emphasized the differences between *O. plumifera* and the allied cold-water species, which lacks the plumose setae on the second basal joints of the feet. The present specimens belong to the latter species, characterized by having four setae on the r.i. of the mandible and a long seta on the r.i. of the first maxilla. It has been figured by Sars under the name of *O. spinirostris* Claus, and is probably identical with that recorded from the Arctic by Mrazek under the name of *O. plumifera*. F. Fruchtl, however (1923), has met with intermediate forms in the Adriatic, and considers the claim of *O. atlantica* to specific distinction doubtful.

14. MICROSETELLA NORVEGICA Boeck.

In small numbers in samples Nos. 2, 3, 5, 6, 7, 8, and more plentiful on the two most westerly stations, samples Nos. 9 and 10. Length, female, 0.48-0.52 mm. Recorded by Mrazek and Smirnov from the Arctic.

15. *ECTINOSOMA FINMARCHICUM* T. Scott. (Fig. 2.)

Most numerous in sample No. 3, 50–0 m. A few specimens also occurred in samples Nos. 8, 9, and 10.

This species seems to be the most distinctly arctic of its genus, having only been recorded, since Scott's (1903) original record from the Varanger Fjord in 70° N., from the neighbourhood of Franz-Joseph Land in $81^{\circ} 10'$ N. and

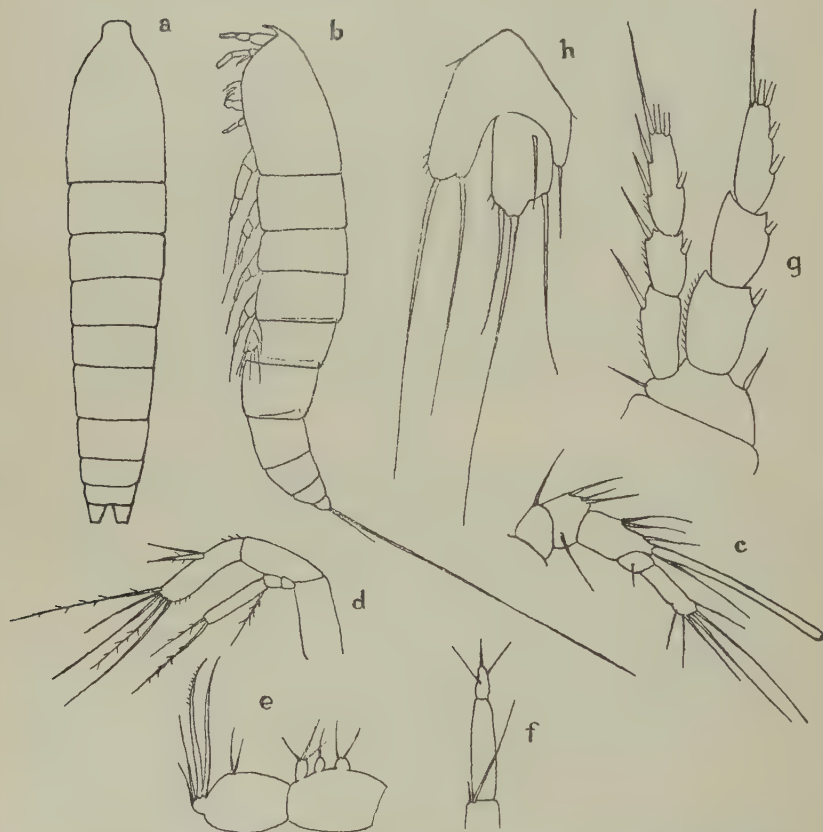


FIG. 2.—*Ectinosoma finmarchicum* T. Scott. Female: a, dorsal view; b, lateral view; c, antennule; d, antenna; e, second maxilla; f, maxillipede; g, first foot; h, fifth foot. a, b $\times 120$; c–h $\times 420$.

$81^{\circ} 54'$ N. (Smirnov, 1932), from the Kara Sea (Aschnov, quoted by Smirnov), and from the North Coast of Alaska (Wiley, 1920). It is also one of the most pelagic, as in the present instance and in Smirnov's record from 25–10 m. over a depth of 334 m.

Wiley and Smirnov both give figures of the fifth feet of the female. These figures agree with my specimens, but differ slightly from Scott's figure, and one

is doubtless justified in assuming that Scott's original brief description and very small figures are not entirely accurate. Scott's female, by inference, measured over 1 mm., Willey's 1.07 mm., and Smirnov's 0.8–0.918 mm.

The differences between this species and *E. wiesei* Smirnov, from Franz-Joseph Land, are slight, and it seems not impossible that the normal range of variation may include both species.

The following description of the *Nautilus* specimens supplements in some points, and modifies in others, Scott's original description:—

Description.—Female, length 0.84–0.88 mm. Colour in formalin an opaque purplish brown, which attracts attention when an unsorted sample is examined by reflected light under a low-power lens. Form of the body (fig. 2 *a*, *b*) slender with long rostral plate curved towards the ventral surface. Margins of abdominal segments finely and uniformly pectinate. Furcal rami about as long as their basal width, conical, with the longest seta about two-thirds as long as the body. Proportional length of furcal setae from without inwards 5, 10, 42, 84, 13. Longest furcal seta 0.56 mm.

Antennules (fig. 2 *c*) five-jointed (six-jointed in Scott's figure). Proportional length of joints measured along lower margin 5, 7, 16, 11, 17. First two joints much thickened. Antennae (fig. 2, *d*) moderately slender, exopodite with the second joint very little longer than the first, endopodite long and slender, three-jointed. Proportional lengths of the joints of the exopodite 33, 37, and of the endopodite 10, 15, 27.

Mandibles and first maxillae with no distinctive features. Second maxillae (fig. 2 *e*) with three lobes on first joint, bearing two, one, and three setae.

Maxillipedes (fig. 2 *f*) with the second joint long and slender.

Swimming-feet (fig. 2 *g*) comparatively slender; the exopodites are distinctly more slender than the endopodites, and bear terminal spines as long as themselves.

Fifth feet (fig. 2 *h*) with the second segment broader and a little longer than the produced part of the basal segment, line of separation between the two segments not clearly marked, setae long and slender.

16. ONCAEA BOREALIS G. O. Sars.

Found at all the stations except one, but only represented by two specimens on the two most westerly stations. On the others it was common. It seems to be commoner below than above 50 m. Sars records it as plentiful off the New Siberian Islands.

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PART III.—REPORT ON THE APPENDICULARIANS.

By Prof. WALTER GARSTANG, M.A., D.Sc., and

ELIZABETH GEORGESON, B.Sc., Ph.D.

Three 'samples' were received from two stations on the north side of Spitzbergen, collected between August 30 and September 4, 1931. They contained 42 Appendicularians, all *Oikopleura vanhoeffeni* Lohmann. Forty were derived from a sample at St. 4, and one from each sample at St. 6. The sample at St. 4 was fished from 50 m. to the surface. One of those at St. 6 was fished from 100–50 m., the other from 50 m. to the surface. Several detached and crumpled houses (3–4 mm.) were also present, and the oikoplastic epithelium of many of the specimens was in a state of activity.

A few very young specimens were present, but most ranged from 2.0 to 2.5 mm. in length of body, and from 10 to 17 mm. in length of tail. The maximum width of body was 1.5 mm., of tail 1.75 mm. The actual numbers in various size-groups are given below :—

Body-length (mm.).	St. 4.	St. 6.		Total.	Tail- length (mm.).	Stations		Total.
		> 50 m.	< 50 m.			4.	6.	
0.5–0.9	2	..	..	2	..	..	..	..
1.0–1.4	..	..	..	..	0.4	2	..	2
1.5–1.9	11	1	..	12	5–9	4	1	5
2.0–2.4	22	..	1	23	10–14	29	1	30
2.5	5	..	..	5	15–17	5	..	5
Total numbers ..	40	1	1	42	..	40	2	42

The *Nautilus* collections are of interest as firmly establishing the Arctic status of *O. vanhoeffeni*. The species had already been taken around Spitzbergen, but in company with *O. labradoriensis* (Römer & Schaudinn, 1898), a species that ranges south of Newfoundland (to 40° N.), and also accompanies *vanhoeffeni* in Davis Strait (Drygalski's Greenland Exped., 1891–3).

On the *Nautilus* expedition, with 5 plankton stations, *O. vanhoeffeni* was the only Appendicularian present, and it was restricted to the two stations where the depth was over 1,500 m., and where ice-cold water (–1.7 to –0.2 C. prevailed to a depth of over 50 m. Its numbers were markedly greatest at St. 4 (81° 50' N., 20° 15' E.; depth, 3,500 m.), where the surface temperature was lowest, and the water was below 0° C. to a depth of at least 100 m. The nets were fished here from 50 m. to the surface (temp. –1.71 to –1.53 C.).

O. vanhoeffeni is known to attain a large size (<7 mm. in body-length), and its floating 'houses' may be as big as cricket-balls. It is noteworthy that the

largest *Nautilus* specimens, while slightly exceeding the maximum recorded length of *O. labradoriensis*, only attained a body-length of 2.5 mm. and a tail-length of 17 mm. All were immature, the gonads being unrecognizable even in the largest specimens.

It is uncertain whether the species extends across the Arctic Sea or not. A large Appendicularian (<6 mm. body-length) was described from the Behring Straits by Mertens in 1831 as *O. chamissonis*, and this, when re-examined, may possibly turn out to be the same species. On this question, and on the distribution of Arctic Appendicularians generally, see Lohmann (1905) and Lohmann u. Bückman (1926). The bearings of the *Nautilus* collection on the life-history of *O. vanhoeffeni* were briefly discussed in Garstang and Georgeson (1935, p. 271).

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The periodic swarming of *Anchistioides antiquensis* (Schmitt) (Crustacea Decapoda) at Bermuda. By J. F. G. WHEELER, D.Sc., F.L.S., Bermuda Biological Station for Research, Inc., and F. A. BROWN, Jun., Ph.D., University of Illinois, U.S.A.

(With 2 Text-figures)

[Read 5 March 1936]

INTRODUCTION.

Between the 7th and the 17th of June, 1934, thirty-six specimens of a prawn, since identified by Dr. Isabella Gordon of the British Museum (Natural History) as *Anchistioides antiquensis* (Schmitt), were captured from the jetty of the Biological Station in the waters of the Reach, between St. George's Island and Long Bird Island, Bermuda. The appearance at the surface of these prawns over the time of the new moon was sufficiently well defined to suggest that further observations would disclose a definite correlation of their activity with the moon's phases. In it also lay a probable explanation of the fact that the working over of the crustacean fauna by Goode, Jones, Verrill, and others had not resulted in the earlier detection of the prawn in these waters. Two or three specimens had, however, been taken in the early part of the summer of 1933 by Dr. J. H. Welsh, of Harvard University, at the same place and in the same manner, but they were not then identified.

Extended observations have been made in 1935 from January onwards, and we wish to thank those who have assisted us in the collection of data, notably Dr. Robert Gurney of Oxford, who was staying at the Station in February and March 1935, to whom we are indebted for some of the earlier records.

The observations were directed mainly to the establishment or otherwise of periodicity. In this paper we have reviewed the data and also some of the possible controlling factors suggested by the data themselves.

METHODS.

The method of collection is a simple one. A 60-watt lamp is hung from the end of the jetty about 2 feet from the surface of the water and the prawns that appear within its light are dipped out with a hand-net. In rough weather a number are missed and escape, but there is good reason to believe that their

stay at the surface is short and that our practice of noting the number seen (in addition to the number caught) is a fair representation of the actual fact. Notwithstanding the constant movement of small fishes and worms, the recognition of *Anchistioides* swimming at the surface becomes easy after a little practice.

The time of the observation period has varied from 7.15 to 8.30 p.m. in the earlier months of the year to 8.45 to 10 p.m. or later in the summer. In order to limit the number of varying factors as much as possible, the method and place of observation have not been changed except where noted in the record, and the majority of the records are by one observer. Some, if not all, of the other factors likely to be concerned are considered below, for at the time of the observation the state of the weather is noted, the direction and approximate force of the wind, the surface temperature, the height of the tide, and the direction of movement of the surface-water.

Directly under the light at the jetty the water is 10 feet deep at low water, increasing outwards to a channel of 14 feet, then again diminishing to the shallows and reefs bordering Long Bird Island. The light used in observation illuminates a half circle of the surface about 4 feet in radius, and at times the water is clear enough for the rocks and mud of the bottom to be distinctly visible. The prawns appear to come up to the surface rather than drift or swim into the light. There is, however, often a current of one or two knots across the end of the jetty producing considerable eddies, and it is practically impossible to be certain whether the prawns rise directly to the surface or are carried there by currents. It is fairly certain that they are not attracted by the light, for on March 7 one was caught in a tow-net from a bridge crossing the channel about a quarter of a mile away to the east of the Station, and no light was used. To this direct evidence of swimming at or near the surface in darkness can be added the many observations on the indiscriminate direction of swimming of the prawns themselves when they appear in the light. Observations made under the light may therefore be considered to represent the general intensity of swarming in the Reach, subject to certain conditions such as similarity of bottom, in which the prawns are assumed to live. No record has yet been made of their capture in daylight in dredges, tow-nets, or in the rocks and mud from the bottom at the jetty brought to the surface in buckets with the aid of the diving helmet, and it is supposed that they live in crevices and holes and only come into the open at the periods of swarming. From the observations given below it will be seen that *Anchistioides* experiences recurrent phases of activity, during which it appears swimming at the surface, such phases being of sufficient intensity at times to merit the term swarming.

TABLE I.—Data on the periodic swarming of *Anchistioides antiguensis* (Schmitt) at Bermuda. Record for 1934 and 1935.

Date.	Time, p.m.	Wind.	Weather.	Sea Temp., ° C.	Anchistioides		Notes.
					seen.	caught.	
1934.							
May 30..	9.0-10.0	..	..	..	..	0	
June 2..	9.30-10.30	..	..	..	..	0	
4..	9.0-10.30	..	..	..	..	0	
7..	10.0-11.0	..	..	..	..	2	without eggs.
9..	9.0-10.0	..	..	..	..	19	3 bore eggs.
13..	9.0-10.0	..	..	..	..	11	all with eggs.
14..	9.30-11.0	..	..	..	..	3	all with eggs.
17..	10.0-10.30	..	..	..	..	1	with eggs.
18..	9.0-10.30	..	..	..	..	0	
19..	9.0-9.45	..	..	..	..	0	
23..	9.30-10.0	..	..	..	..	0	
26..	10.0-10.30	..	..	..	..	0	
July 11..	8.15-9.45	SSW.	calm.	..	..	0	
12..	8.30-9.45	SW.	cloudy, rain.	..	..	0	
13..	8.45-10.30	SW.	..	..	..	0	
14..	8.45-9.50	SW.	rough, rain.	..	..	0	
15..	9.0-10.10	..	cloudy.	..	..	0	
16..	8.45-10.0	..	calm, cloudy.	..	..	1	
17..	8.45-10.30	..	cloudy.	..	..	0	obs. J. K. D.
18..	8.30-9.45	W.	rain.	..	..	0	
19..	8.55-9.45	E.	calm.	..	..	0	
1935.							
Jan. 23..	9.10-10.0	SE. 20.	moon up, 10.0 p.m.	..	0	0	
24..	8.50-10.0	N. 5.	clear.	..	0	0	
25..	8.20-10.30	..	..	..	0	0	obs. M. B.
Feb. 2..	8.10-9.45	N. 5.	still, starlight.	..	0	0	
5..	9.0-9.45	NW. 5.	..	..	0	0	
7..	8.40-9.50	N. 5.	cloudy.	15.7	0	0	
8..	9.15-9.45	E.	cloudy.	15.6	0	0	
9..	8.45-9.45	SSW.	moon, starlight.	16.6	0	0	
11..	9.05-9.40	..	cloudy.	16.4	0	0	
13..	7.45-8.30	NE. 5.	cloudy.	16.5	0	0	tow.
18..	{ 8.07-8.27 8.30-8.40 }	{ WSW. 5.	cloudy, rain.	..	0	0	tow.
21..	7.15-8.15	..	..	..	..	4	obs. R. G.
22..	7.30-8.0	..	..	..	0	0	obs. R. G.
23..	7.15-8.15	..	..	..	..	1	obs. R. G.

TABLE I. (cont.).

Date.	Time, p.m.	Wind.	Weather.	Sea Temp., °C.	<i>Anchistioides</i>		Notes.
					seen.	caught.	
1935.							
Feb. 24..	8.10-9.15	..	..	18.5	0	0	obs. R. G.
25..	8.0-9.30	..	calm, starlight.	..	6-7	4	obs. R. G.
26..	7.30-8.30	..	..	..	0	0	obs. R. G.
27..	7.30-8.15	} ..	..	..	0	0	tow, obs. R. G.
	7.35-8.15		..	..	0	0	
Mar. 7..	8.35-8.50	..	..	19.0	..	1	tow, obs. R. G.
8..	7.30-8.30	..	..	..	0	0	tow, obs. R. G.
9..	7.45-8.30	..	cloudy.	..	0	0	obs. R. G.
10..	7.30-8.30	..	..	..	0	0	obs. R. G.
12..	7.38-8.10	SW. 5.	moon.	..	0	0	tow.
16..	8.0-8.45	..	..	..	0	0	obs. R. G.
21..	7.30-8.15	..	calm.	..	..	1	obs. R. G.
26..	7.30-9.0	..	..	..	..	3	obs. R. G.
27..	8.0-9.30	..	..	..	..	5	obs. R. G.
28..	8.0-9.0	..	..	..	0	0	obs. R. G.
29..	..	..	..	..	0	0	tow, obs. R. G.
30..	8.0-8.15	} ..	..	..	0	0	tow, obs. R. G.
	8.30-9.0		..	..	0	0	
31..	8.0-8.30	..	..	..	0	0	obs. R. G.
April 4..	7.55-8.55	SW. 15.	rain.	20.5	3	2	
5..	8.30-9.30	SW.	rain.	..	0	0	
7..	8.35-9.30	SW. 5.	..	20.5	0	0	
10..	8.55-9.25	W. 10.	..	..	0	0	
15..	8.10-8.40	..	..	..	0	0	
27..	9.15-9.45	nil.	still.	20.0	1	0	
28..	9.40-10.0	SW. 10.	starlight.	..	6	0	
30..	7.50-8.50	SW. 20.	cloudy.	21.5	38	25	
May 1..	7.45-8.50	} NE. 10.	..	21.0	..	2	1st 9.05, 2nd 9.15.
	8.55-9.35		..	..	..	..
2..	8.40-9.40	NE. 5.	starlight.	21.5	1	1	9.10.
3..	9.20-9.40	SW. 5.	starlight.	22.0	2	2	1st 9.25, 2nd 9.30.
4..	9.25-9.55	SW. 15.	starlight.	..	6	4	
5..	8.45-9.15	E. 15.	cloudy.	22.0	25	14	
7..	9.25-9.55	SW. 10.	..	..	1	0	9.40.
14..	8.45-9.30	SW. 5.	cloudy.	22.5	0	0	
17..	9.15-9.45	W. 5.	cloudy.	23.5	0	0	
19..	9.0-9.45	W. 5.	starlight.	23.1	0	0	
22..	9.0-9.30	SW. 25.	rough.	22.8	0	0	
25..	9.05-9.45	..	starlight.	23.1	1	1	
28..	8.50-9.30	E. 8.	starlight.	24.0	20	9	
29..	8.45-9.30	NE. 5.	starlight.	23.9	1	1	
31..	9.25-9.55	SW. 5.	cloudy.	25.0	2	1	

TABLE I (cont.).

Date.	Time, p.m.	Wind.	Weather.	Sea Temp., ° C.	Anchistioides		Notes.
					seen.	caught.	
1935.							
June 2..	8.35-9.30	NW. 5.	starlight, clouds.	24.5	1	1	
4..	8.55-10.0	W. 5.	cloudy.	23.7	19	10	7 with eggs.
6..	8.45-9.45	W. 5.	moon, cloudy.	24.0	7	4	1 with eggs, 1st 9.15.
7..	9.0-10.0	..	still.	24.0	0	0	
9..	9.10-9.40	SSW. 5.	moon, cloudy.	24.0	0	0	
10..	9.15-10.0	SW. 10.	moon, cloudy.	24.5	0	0	
12..	9.10-10.10	nil.	still.	25.0	0	0	
14..	8.38-9.40	WSW. 5.	clear.	26.5	0	0	
16..	9.0-9.20	..	..	..	0	0	obs. J. H. W.
17..	8.35-9.50	WSW. 10.	clear.	27.0	1	1	9.10.
18..	8.35-9.30	..	calm.	..	0	0	obs. J. H. W.
19..	9.0-9.45	WSW. 5.	clear.	27.0	1	1	9.10, with eggs.
20..	8.45-9.30	..	..	..	0	0	obs. J. H. W.
21..	9.15-10.05	SW. 5.	clear.	..	0	0	
23..	8.58-10.05	S. 5.	clear.	..	3	1	1 with eggs; 9.20, 9.25, 9.35.
24..	8.40-10.0	SW. 5.	clear.	28.0	18	8	6 with eggs; 1st 8.50, last 9.50.
25..	8.30-9.45	W.	after rain.	28.0	34	18	4 with eggs; also stage 1 larvae.
26..	8.30-9.45	nil.	starlight, after rain.	27.0	30	18	2 with eggs.
27..	8.30-10.0	NE. 5.	thunder, cloudy.	..	24	14	6 with eggs, obs. J. H. W.
29..	8.40-9.45	SE. 5.	starlight, clouds.	26.0	15	9	none with eggs, obs. with J. H. W.
July 1..	8.30-9.0, 9.0-10.0	} SW. 5.	starlight, clouds.	27.0	3	1	obs. with A. A. 1st 9.10, last 9.45, none with eggs.
2..	8.35-10.0		starlight, clouds.	26.5	7	1	
3..	9.0-10.05	SE. 5.	starlight, clouds.	26.0	3	2	2 with eggs seen, none after 9.20.
4..	8.27-9.50	SE. 10.	starlight, clouds.	26.0	2	0	none with eggs.
5..	8.30-10.0	SSW. 10.	cloudy.	25.5	1	1	without eggs. 9.05.
6..	8.30-9.20	..	cloudy, rain.	..	1	0	
7..	8.30-9.50	W. 5.	cloudy.	..	0	0	
8..	8.30-9.50	SW. 5.	cloudy.	..	0	0	
9..	8.40-10.0	SW. 5.	clear.	..	0	0	

TABLE I (cont.).

Date.	Time, p.m.	Wind.	Weather.	Sea Temp., ° C.	<i>Anchistioides</i>		Notes.
					seen.	caught.	
1935.							
July 10..	8.40-10.0	nil.	still.	27.0	0	0	obs. A. A.
11..	9.0-9.55	SW. 5.	clear.	..	0	0	
12..	8.30-10.0	SW. 10.	moon, starlight.	28.0	0	0	
14..	8.50-9.30	SW. 5.	moon, starlight.	28.5	0	0	
15..	8.50-9.30	SE. 10.	moon, clouds.	28.5	0	0	
16..	8.35-9.50	SE. 5.	moon, starlight.	28.5	0	0	
17..	9.15-9.45	E. 10.	moon, starlight.	29.0	0	0	
18..	9.10-9.45	E. 5.	..	..	0	0
19..	9.0-9.45	ENE.	calm.	28.5	0	0	
21..	8.55-9.50	..	calm.	..	0	0	
22..	8.50-10.05	..	calm.	..	0	0	8.35. 8.45, 9.0.
24..	8.35-9.50	S. 5.	starlight.	29.1	1	1	
25..	8.40-9.50	S. 5.	starlight.	29.7	2	2	
26..	8.40-9.40	SW. 10.	clear, after rain.	28.6	0	0	
27..	8.35-9.45	SW. 5.	starlight, lightning to S.	28.8	1	1	
30..	8.25-9.0	W. 20.	starlight, squalls.	28.2	0	0	
31..	8.30-9.30	W. 15.	starlight.	28.4	0	0	
Aug. 1..	8.30-9.40	SW. 20.	starlight, clouds.	..	0	0	
2..	8.15-9.15	WSW. 5.	starlight.	28.6	0	0	
4..	8.15-9.30	W. 20.	clouds.	28.7	0	0	
5..	8.35-9.30	WSW. 15.	clouds.	28.4	0	0	
6..	8.40-9.30	WSW. 15.	clouds.	28.0	0	0	
8..	7.55-9.20	SW. 10.	clouds, after rain.	27.4	0	0	
9..	8.25-9.25	SW. 5.	clouds, moon.	27.4	0	0	
11..	8.43-9.35	W. 5.	clouds.	27.3	0	0	
12..	8.40-9.30	SW.	still, cloudy.	27.6	0	0	
13..	9.20-9.50	W. 5.	clear.	27.7	0	0	
14..	8.50-10.10	SW. 5.	clear.	27.8	0	0	
15..	8.50-10.10	N.	clear.	27.9	0	0	
16..	9.0-10.10	E.	calm, clear	28.1	0	0	

TABLE I (cont.).

Date.	Time, p.m.	Wind.	Weather.	Sea Temp., °C.	<i>Anchistioides</i> .		Notes.
					seen.	caught.	
1935.							
Aug. 17..	8.0-10.0	ESE. 5.	clouds, starlight.	28.2	0	0	
18..	8.25-10.0	ESE.	still, starlight.	28.4	0	0	
19..	8.30-9.25	E.	calm.	28.3	0	0	
20..	8.45-9.30	E. 10.	starlight.	28.2	0	0	
21..	8.40-9.30	E. 15.	cloudy, after rain.	27.3	0	0	
22..	7.50-8.35	E. 30.	clouds, hurricane warning.	26.6	0	0	
23..	6.45	..	..	26.3	..	..	too rough for obs.
24..	8.0-9.30	SW. 5.	cloudy, rain at intervals.	26.8	0	0	
25..	8.30-9.30	SW. 10.	cloudy, rain.	26.5	0	0	
26..	8.55-9.45	nil.	cloudy.	26.3	0	0	
27..	9.10-10.0	SW. 5.	starlight.	26.2	3	2	1 on surface, others 1 ft. below.
28..	8.45-9.45	E. 5.	starlight.	27.2	0	0	
29..	8.20-9.20	E. 5.	starlight.	27.5	3	3	8.25, 9.0, 9.15.
30..	8.25-9.25	SE. 5.	starlight.	27.8	10	2	
31..	8.40-9.20	S. 5.	starlight.	28.0	2	2	8.55, 9.0.
Sept. 1..	7.55-9.15	S. 5.	starlight, lightning to S.	28.1	1	1	8.30.
2..	8.20-9.15	S. 5.	starlight, moon just going down.	28.1	3	2	8.30, 8.40, 8.55.
3..	8.25-9.25	S.	starlight.	28.3	0	0	
4..	8.15-9.20	SE.	starlight, clouds.	28.3	0	0	
5..	8.0-9.0	S. 10.	starlight, moon up.	27.9	0	0	
6..	8.0-9.05	S. 5.	starlight, moon.	28.4	0	0	
7..	8.05-9.05	WSW. 5.	clear.	28.1	0	0	
8..	8.10-9.10	SW. 5.	cloudy.	28.4	0	0	

NOTE.—We wish to thank the following visitors at the Station for their help in observing the appearances of *Anchistioides*:—Dr. J. K. Donahue (Princeton); Dr. M. Burkenroad (Yale); Dr. R. Gurney (Oxford); Dr. J. H. Welsh (Harvard); Dr. A. Abramowitz (Harvard).

EVIDENCE OF LUNAR CONTROL.

The original data suggesting a lunar periodicity are represented graphically in fig. 1 (inset), and it will be seen that of twelve observations taken at two- or three-day intervals over the period from May 30, two days after the full moon, to June 26, the night before full moon, no specimens were seen outside the ten-day period which roughly straddled the time of the new moon. Observations on nine days in July resulted in the capture of a single specimen five days after the new moon. It will be noted in addition from Table I that the June period was a time of reproductive activity.

The observations in 1935 are represented in fig. 1. A periodic swarming is evident, as it was in 1934, coincident in April-May, May-June, June-July, and August with the period between the last quarter and first quarter of the moon. Taken by themselves the data for the months of February, March, and April do not encourage the theory of a rhythm coinciding with the new moon. They suggest rather the occurrence of a somewhat rare form which makes its appearance in small numbers at no definite time during the lunar cycle. As only a single observation was made during the period from March 1 to 6 over the new moon in this month, and no observation was recorded in the three days at the beginning of April, again over the new moon, in addition to the incompleteness of the record over the whole period, there is no conclusive evidence of periodicity of any kind, but taken in conjunction with the very definite periodicity during the four succeeding lunar periods the scattered observations suggest that there is at least a continuity of rhythm with the later observations. Two possibilities suggest themselves: (1) there may be a rhythm unconnected with the moon, which by coincidence of manifestation in the summer with the new moon has been wrongly attributed to lunar influence; (2) there may be a periodicity of appearance connected with the time of the new moon, and therefore, in some way controlled by it, definitely marked during the season of reproduction and at other times obscured by some unknown factor or simply dormant, depending upon whether the observations represent a definite period of occurrence between the full moon and last quarter in February and a somewhat later period in March, or whether, had there been sufficient observations, no periodicity would have been apparent.

In June 1934 the most productive time of observation had been from 9.15 to 9.45 p.m. In consequence, the prawns were expected to appear between 9 and 10 p.m. if they were active at all. It is probable, therefore, that the time of observation was often later than it should have been in the earlier months. All the specimens taken by Gurney were caught early in the evening, and the possible significance of a definite interval following the time of sunset before the onset of swarming had escaped attention until then. At this time the observations were directed entirely to the absence or presence of the prawns with a view to establishing the fact of periodicity.

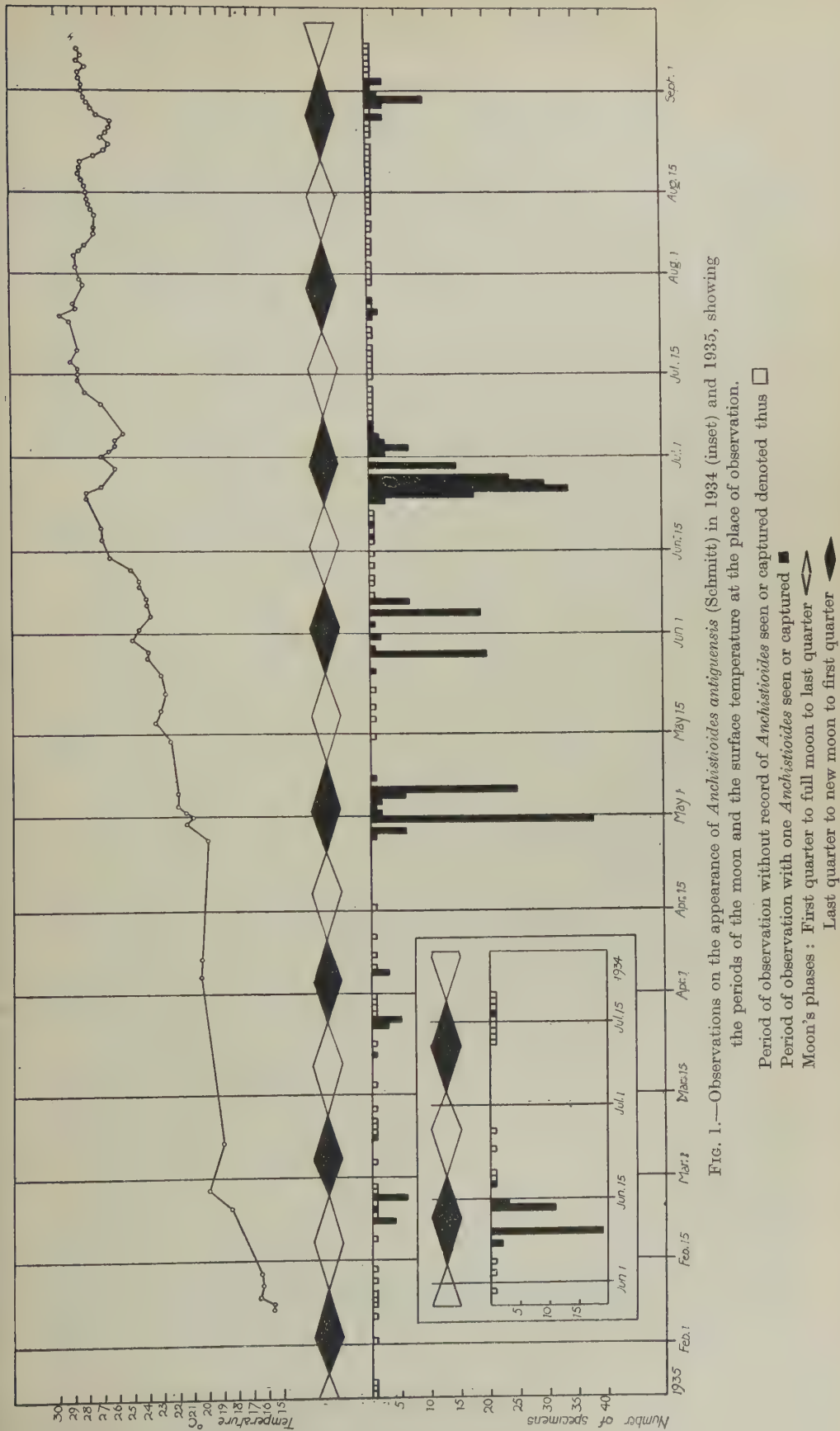


FIG. 1.—Observations on the appearance of *Anchistoides antiguensis* (Schmitt) in 1934 (inset) and 1935, showing the periods of the moon and the surface temperature at the place of observation.

Period of observation without record of *Anchistoides* seen or captured denoted thus □

Period of observation with one *Anchistoides* seen or captured ■

Moon's phases : First quarter to full moon to last quarter ◊

Last quarter to new moon to first quarter ◆

It is not now considered that *Anchistioides* comes to the surface at any time during the night at the appropriate period of the moon. Consider, for instance, the evening of May 1, when watch was kept from 7.45 to 8.50 and again from 8.55 to 9.35 p.m. After an hour and twenty minutes two specimens were taken within ten minutes of one another, and twenty minutes followed this brief period of activity during which time no more were seen. Further examples may be picked out from the record showing that the surface swarming is limited to a definite period during the evening.

There is no evidence of a shifting of this period progressively earlier or later during any one sequence of surface swarmings, and it has been taken for granted, perhaps prematurely, that on nights when no swarming has been recorded it has not occurred later in the night. There is, however, some evidence of a shift in the time of appearance later in the evening as the season advances, from the already mentioned fact that in February and March observations were made earlier than those in May, June, and July. Sunset at the end of February is about 6.15 p.m., while in June it is about 7.30 p.m. Almost all the collections were made later than one hour after sunset during the succeeding two hours.

Observations in June, July, and August are conclusive in showing that swarming occurs during the period from the last quarter of the moon over the new moon and up to the first quarter. From the full moon of May 18 to the full moon of August 15 thirty-three observations during the swarming period resulted in the record of 196 prawns on twenty-two occasions, while thirty observations made outside the limits laid down produced but two records, one prawn appearing during the evening of June 17 and another on June 19.

It will be evident from fig. 1 that the swarming is not a simple increase and decrease in numbers over a stated period. There are two definite maxima of frequency at each period with an interval of several days between them. The first maximum grows in importance with each swarming, while the second diminishes, for it is only faintly discernible in the June-July period, and not apparent after that. If lunar influence were itself responsible for swarming, there does not seem to be any reason why there should be a double maximum. One maximum would be expected over the time of the new moon. The possibility that some other factor is involved is strengthened by the occasional appearances of prawns outside the limits of the swarming period.

The double maximum at first sight suggests a segregation of the sexes. Indeed, the phenomenon of periodicity itself is linked with reproduction in so many animals that its occurrence in *Anchistioides* led naturally to consideration of the breeding habits and an attempt at an explanation of swarming based on them.

THE INFLUENCE OF SEX AND THE REPRODUCTIVE PERIOD.

The increased frequency of appearance of the prawns in the summer, together with the presence of developing eggs at that time inevitably suggests a connexion between swarming and the reproductive habits. Further consideration shows

that the connexion, if any, is obscure, for apart from the fact that periodic activity takes place on a small scale outside the limits of the breeding season, the swarming does not appear to be correlated with any act of reproductive significance. In the Palolo worm, for instance, swarming at the surface only occurs at the liberation of spermatozoa and eggs, and the same is true of the "Fire-worm", *Odontosyllis*, in Bermuda waters. In *Anchistioides*, however,

TABLE II.—*Anchistioides antiguensis* (Schmitt).
Sex of the available specimens.

Date.	Number seen.	Number caught.	Males.	Females.	Remarks.
4. iv. 35.	3	2	1	1	
30. iv. 35.	38	25	9	15	
2. v. 35.	1	1	..	1	
3. v. 35.	2	2	1	1	
4. v. 35.	6	5	3	2	
5. v. 35.	25	14	4	10	
25. v. 35.	1	1	1	..	
28. v. 35.	20	9	1	8	1 ♀ with eggs.
29. v. 35.	1	1	1	..	
31. v. 35.	2	1	..	1	
4. vi. 35.	19	11	? 2	9	all ♀ with eggs.
6. vi. 35.	7	4	..	1	with eggs.
19. vi. 35.	1	1	..	1	with eggs.
23. vi. 35.	3	1	..	1	with eggs.
24. vi. 35.	18	8	? 2	6	all ♀ with eggs.
25. vi. 35.	34	14	8	5	4 ♀ with eggs.
26. vi. 35.	30	18	8	5	all ♀ with eggs.
27. vi. 35.	24	14	..	..	6 with eggs.
29. vi. 35.	15	9	..	..	none with eggs.
1. vii. 35.	3	1	..	..	none with eggs.
2. vii. 35.	7	1	1	..	2 with eggs seen.
3. vii. 35.	3	2	2	..	
5. vii. 35.	1	1	1	..	
25. vii. 35.	2	2	2	..	
27. vii. 35.	1	1	1	..	
27. viii. 35.	3	2	..	2	
29. viii. 35.	3	3	1	2	
30. viii. 35.	10	2	1	1	

the rhythm affects immature examples of both sexes, females with fertilized eggs and adult males, and although on June 25 some stage 1 larvae were found swimming at the time of swarming, liberation of the larvae does not usually take place for some days after capture. Two of the females with eyed eggs taken on June 4 were segregated in the morning of the day following capture, and stage 1 larvae were not seen until five days afterwards. Again, it was noted in June 1934 that larvae were hatched out some days after capture.

The available records of sex are given in Table II (p. 423), and there are sufficient to show that there is no pronounced predominance of one sex at any time. Females appear to outnumber males in the earlier swarmings of the summer, becoming less frequent later, and finally, from the few captures made, giving place to males, until the next generation make its appearance at the end of August.

This change in the frequency of the sexes, supposing it to be a normal occurrence, is evidently only incidental to the rhythm of the swarming periods. It does not bear directly on the problem of their incidence or persistence; and the capture of both sexes at the two maxima of each swarming shows that the phenomenon of double periodicity is unconnected with sex.

THE INFLUENCE OF TEMPERATURE.

The surface temperature at the jetty on February 23, 1935, at 9.0 a.m. was 17.4°C. , and a specimen of *Anchistioides* was taken in the evening. In March the temperature recorded on the 26th was 18° in the morning, and three specimens were taken that day. At the April-May swarming the temperatures ranged from 20.5° to 22.0° , and at each swarming thereafter the temperature had risen until on 25 July two specimens were caught with the temperature at 29.7°C.

While the general rise in temperature through the summer cannot be said to affect the rhythm, it was thought that temperature might be a controlling factor when in its fluctuations from day to day it took a downward trend. This theory, borne out by some of the records, is definitely opposed by others, and it is concluded that neither temperature nor changes of temperature can be considered as significant factors (fig. 1).

THE EFFECT OF WIND AND WEATHER.

When the records are examined with a view to correlating the swarmings with the wind or weather, the conclusion is soon reached that no connexion exists. Taking some of the maximum swarmings and comparing the winds—April 30, wind SW 20, with clouds; May 5, wind E 15 with clouds; June 4, wind W 5 with clouds; June 24, wind S 5–10, starlight; June 25, wind W, starlight, lightning far off, after heavy rain; June 26, wind nil, starlight and clouds after heavy rain; June 27, wind NE 5, clouds with thunder and lightning; June 29, wind SE 5–10, starlight and clouds—it is obvious that swarming is independent of wind and weather unless it is affected by heavy rain at the time, this being almost the only weather in which records of the appearance of *Anchistioides* have not been made. On August 24, however, after heavy rain and with rain at intervals during the period of observation, fifty-three specimens of *Peneopsis smithi*, a prawn which appears to have habits very similar to *Anchistioides*, were seen at the surface, so that probably rain is not a deterrent to swarming.

THE INFLUENCE OF THE TIDE.

In so far as tidal movements are related to the moon's changing phases, swarming may be correlated with the rise and fall of the tide during the period of the new moon which is greater than at any other period in the lunar cycle, but it appears to bear no relation to other tidal phenomena.

Table III has been compiled from the data supplied by the U.S. Coast and Geodetic Survey, Washington, from the record obtained by an automatic tide-

TABLE III.—*Observations of Anchistioides and the state of the tide.*

Date.	Time of high water, p.m.	Time of low water, p.m.	Time of collection, p.m.	State of tide.	<i>Anchistioides</i> , number seen.
April 27..	3.48	10.0	9.15-9.45	Falling, near l.w.	1
28..	4.42	11.0	9.40-10.0	Falling, near l.w.	6
30..	6.35	midnight.	7.50-8.50	Falling, near h.w.	38 (2)
May 1..	7.24	1.0	7.45-8.50, 8.55-9.35	H.w., falling to half- tide.	2
2..	8.6	1.48	8.40-9.40	Falling, near h.w.	1
3..	8.42	2.24	9.20-9.40	Falling, near h.w.	2
4..	9.30	2.54	9.25-9.55	H.w. and falling.	6 (1)
5..	10.0	3.42	8.45-9.15	Rising, near h.w.	25
7..	11.54	5.24	9.25-9.55	Rising, after half-tide.	1
25..	2.0	8.6	9.05-9.45	Rising, near l.w.	1
28..	5.0	11.36	8.45-9.30	Rising, after half-tide.	20
29..	5.54	midnight.	8.45-9.30	Rising, half-tide.	1
June 2..	9.24	3.0	8.35-9.30	Rising, near h.w.	1
4..	11.0	4.36	8.55-10.0	Rising, near h.w.	18 (9)
6..	midnight.	5.54	8.45-9.45	Rising, half-tide.	7 (7)
23..	2.0	8.18	8.58-10.05	Rising, near l.w.	3 (8)
24..	3.0	9.12	8.40-10.0	L.w. and rising.	18 (6)
25..	4.6	10.42	8.30-9.45	Falling, near l.w.	34 (5)
26..	4.54	11.54	8.30-9.45	Falling, after half-tide.	30 (4)
27..	6.06	midnight.	8.30-10.0	Falling, half-tide.	24 (3)
29..	7.42	1.12	8.40-9.45	Falling, near h.w.	15

recording machine situated close beside the jetty from which the observations on *Anchistioides* were made. Swarming has been observed when the tide is (1) at high water and falling; (2) near high water and falling; (3) at half tide and falling; (4) after half tide and falling; (5) near low water and falling; (6) at low water and rising; (7) near low water and rising; (8) at half tide and rising; (9) near high water and rising. It is therefore evident that swarming is independent of the rise and fall during each tidal day.

OTHER EXTERNAL PHYSICAL CONDITIONS.

The direction of the flow of water past the jetty has been proved of no value, since the surface-water is affected by the prevailing wind and eddies caused by the jetty itself, and may move in a contrary direction to the current beneath. The clearness or otherwise of the water has not received much attention, mainly because on one occasion only in the 1935 observations has the bottom been visible, and since it has been shown that the prawns do not appear to be attracted directly to the light, data on penetration did not seem to bear on the problem.

INFLUENCE OF FEEDING HABITS.

It did not appear likely that the short periods of swarming could be migrations in search of food at roughly monthly intervals, and the possibility that the feeding habits of the animal might be controlled by light was not realized. It is evident, however, that an explanation of swarming can be based on short nocturnal migrations for food in the course of which the prawns reach the surface on dark nights. *Anchistioides* is a strictly nocturnal form from its appearance and habits in captivity. The fact that it has never been recorded in daytime confirms the theory that it lurks in holes and crevices during the day and only ventures out in darkness. Examination of the gizzard contents of six males and a female taken in June were disappointing, for they were all completely empty. It was then realized that nearly all the preserved specimens had been kept in captivity for a night at least and often longer. Two females with developing eggs taken in June had been fixed directly after capture and the gizzards were found to be full of worm setae. Setae were also found in the gizzard of the larger of the specimens taken on 27 August.

While there is evidence, therefore, that the prawns that come to the surface have recently fed, this is by no means proof that their appearance there is due to the method of feeding. If it were so, one would expect to find them at the surface on any night of the lunar cycle provided that the moon was not up or was sufficiently obscured by clouds, yet there is no record of such general movements. A far more likely explanation lies in the movements of the worms upon which they feed. *Odontosyllis enopla* Verrill is known to appear at a very definite time after sunset, sometimes two, but more often three days after the full moon in the summer for the liberation of eggs and spermatozoa. Each appearance is of about twenty minutes' duration, though sometimes it lasts longer, and it may continue for a week or more. The setae from *Anchistioides* do not belong to *Odontosyllis* and they have not yet been identified, but there is sufficient reason to suggest that the true causative factor of periodicity in the prawns will be found in the periodicity of its food.

THE INFLUENCE OF GROWTH.

Measurements of preserved specimens from the tip of the rostrum to the posterior end of the carapace in the mid-dorsal line (fig. 2) indicate an increase in length from April onwards, of which the most noticeable feature is shown by the captures on April 30 as compared with those of May 4 and 5. Measurements of twenty-four specimens of April 30 average 0.93 cm., while nineteen specimens of the later dates average 1.04 cm. Now these dates are included in one swarming period; but they represent the two maximum appearances of the prawns, which are thus shown to differ in the stage of growth reached by the majority of

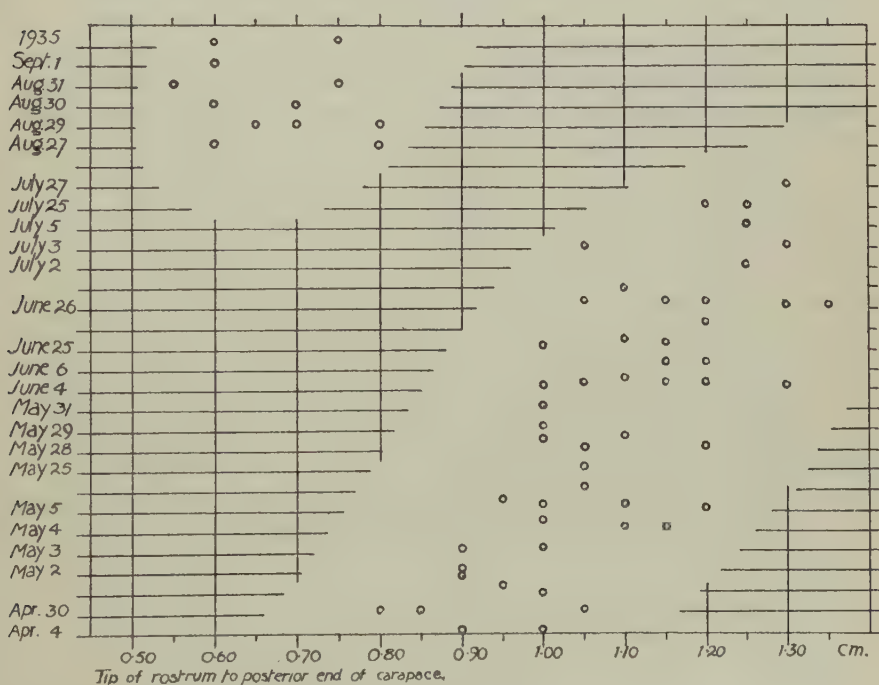


FIG. 2.—*Anchistioides antiquensis* (Schmitt). Frequency of measured individuals of both sexes in 1935. Each vertical interval indicates five individuals.

individuals of which they are composed. At the next swarming period the difference between the measured individuals at the maxima is perceptible, though by no means marked, and it is likely that the slowing down of growth as it nears the limits of bodily size is here coming into play.

At the end of August and beginning of September twenty-two specimens were seen and twelve of them captured. All were of small size. They represent obviously the first of next year's swarmings, though whether they are already one year old or of the present year's hatching remains to be discovered.

SUMMARY.

Observations from the jetty of the Biological Station, Bermuda, of the appearance of *Anchistioides antiquensis* (Schmitt) at the surface over a short period in 1934 and eight months in 1935 are recorded, and show definite periodicity sometimes of sufficient intensity to merit the term swarming.

The periodicity coincides with the two weeks of the lunar cycle when the moon wanes from the last quarter to the first quarter of the new cycle. It appears to consist of two maximum appearances separated by an interval of some days.

Direct lunar influence, sex and the reproductive period, the surface-temperature, wind and weather, and the state of the tide are shown to have no connexion with swarming.

An explanation is suggested based on the feeding habits and depending on the periodic activity of the worms that form the food. The double maximum of the swarming period is shown to represent two stages of growth.

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On the feeding mechanism of the nauplius of *Balanus perforatus* Bruguière.

By JOHN H. LOCHHEAD. (Communicated by Prof. J. STANLEY GARDINER, M.A., F.R.S., F.L.S.)

(With 6 Text-figures)

[Read 5 March 1936]

INTRODUCTION.

The work here described was carried out during the summer of 1934 at the Stazione Zoologica, Naples, where I occupied the Cambridge University Table. It forms part of a general survey of feeding mechanisms of crustacean nauplii, further results of which will be published later. I am indebted to many who helped me at Naples, especially Dr. Dohrn, Professor Ranzi, and Professor Just. I have also to thank Dr. L. A. Borradaile for much useful advice and criticism.

METHODS.

Adult *Balanus* were collected and brought into the laboratory, where they were kept in jars of circulating sea water. Numerous nauplii were usually set free within a few hours. They collected on the side towards the light, and by drawing off the circulating water from the other side a minimum of nauplii was lost. The nauplii were removed to smaller jars, where they were given a rich phytoplankton mixture as food. It was found unnecessary to change the water.

The living nauplii were observed under a raised cover-slip, carmine particles or diatoms being used to indicate the currents. For studying the morphology the chitinous skeletons of dead individuals cleaned out by protozoa, or occasionally the cast skins, were used in preference to whole animals. All drawings were made with the camera lucida from specimens mounted in water.

THE REARING OF THE NAUPLII OF *BALANUS*.

When work was started in April, a few nauplii developed right through to the cypris stage in about three weeks. Thus all the stages were obtained, but unfortunately at this time I had not realised that these are so little known, and therefore made no attempt to distinguish them. In later efforts to rear the nauplii none ever passed the second moult, though some lived three weeks, an experience similar to that of Groom (1894). In a second paper, indeed, Groom (1894-95) describes six naupliar stages for *Balanus perforatus*, but

though he does not state the source it seems clear that all but the first two of these were obtained from plankton hauls.

In the literature I can find only two references to the successful rearing of *Balanus*. Coker (1901) mentions obtaining cyprides from the nauplii of 'smooth *Balanus*' growing on the backs of crabs. And recently Herz (1933) has given a good description of eight naupliar stages of *Balanus crenatus*, which he reared in the laboratory. At Naples I found in conversation with Professor Just that he had successfully reared *Balanus* (probably *perforatus*) at the same time (April) as myself. It was interesting to find that we had both used the same food and methods.

The factors concerned in the successful rearing of cirripede nauplii have long puzzled investigators. Delage (1884) gives lengthy instructions for the rearing of the nauplii of *Sacculina*. He showed that it is the quality of the nauplii rather than the environment which is important*. Only absolutely ripe adults yield nauplii vigorous enough to pass all the moults; other adults often yield nauplii, but this is an abortive emission due to the shock of transportation, and such nauplii are not healthy. The case of *Sacculina* is simplified, since the nauplii do not feed, but nevertheless Delage has probably revealed the most important factor for cirripede nauplii in general. Thus Nilsson-Cantell (1921) notes that the larvae of aquarium cirripedes are usually more easily set free than is the case in nature. At Naples in 1934 *Balanus perforatus* bred very much more freely in April than later in the year. Thus at this season occurred the best chance of obtaining an absolutely ripe adult.

Herz (1933) made many unsuccessful attempts to rear the nauplii of *Balanus* before he tried using barnacles found growing in a muddy 'slough'. His success with these he attributed to the greater hardiness of the nauplii, which were accustomed to an unfavourable environment.

THE STAGES OF THE NAUPLIUS OF *BALANUS PERFORATUS*.

At Naples *Balanus perforatus* leaves the egg at a stage corresponding to the second of *B. crenatus* as described by Herz. Judging from the literature, this is probably normal for most species of *Balanus*, the earlier stage described by Herz being exceptional. But the stage at which cirripede larvae are set free is known to be variable and more exact work is needed. Broch (1924) has made an interesting forecast of the probable duration of a free-swimming naupliar phase for many northern species, based purely on the ecology of the adults.

The first stage of *Balanus perforatus* is very simple in structure and does not normally feed. Under aquarium conditions about half an hour after hatching it moults to the second stage, which is much better developed and feeds actively. Succeeding stages are larger and better provided with setae and setules, but

* In a recent very interesting account of the rearing of *Alcippe lampas*, the nauplius of which, like that of *Sacculina*, does not feed, Kühnert (1934) stresses both the quality of the brood and a number of environmental factors.

must feed in essentially the same manner as does the second. The following description refers to the second stage (fig. 1), and the first stage will be dealt with later.

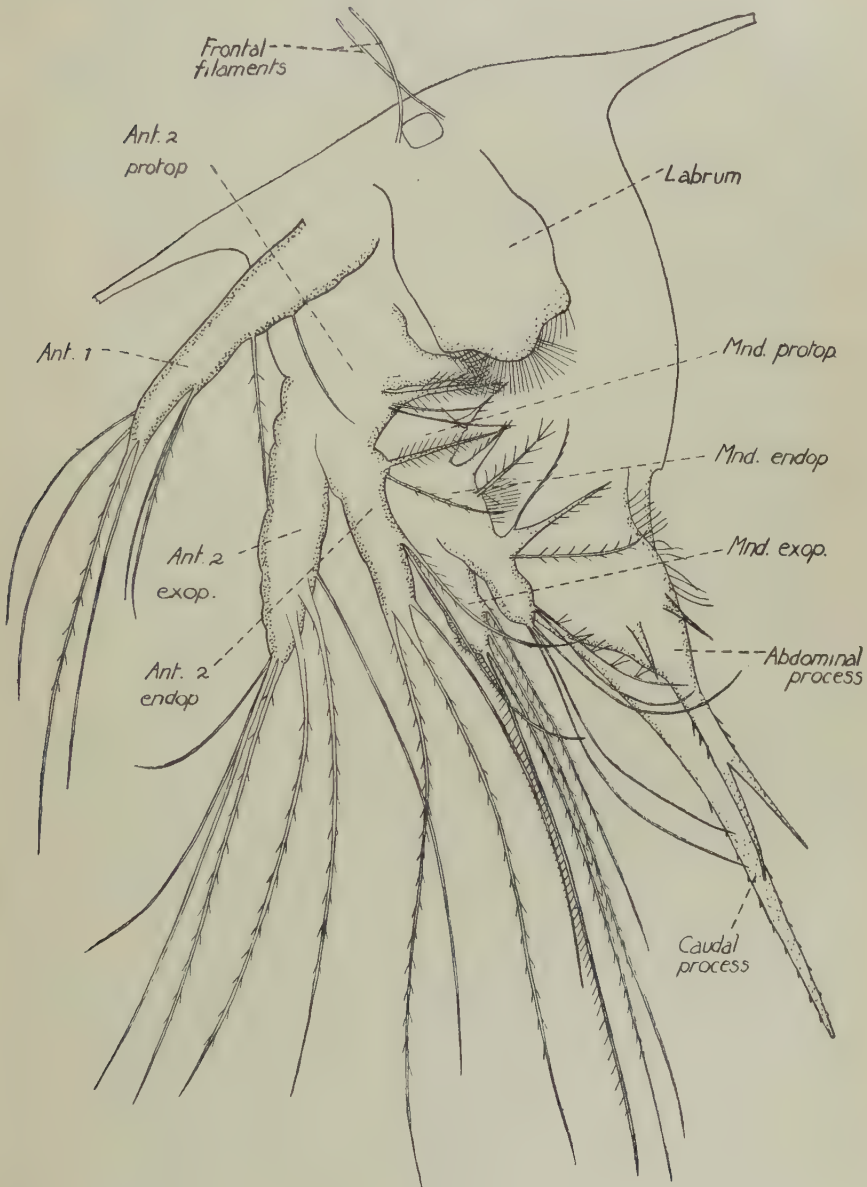


FIG. 1.—Ventral view of second stage nauplius of *Balanus perforatus*.
Limbs of left side and body spinules not shown.

THE MORPHOLOGY OF THE LIMBS IN THE SECOND STAGE.

There are three pairs of limbs. The first, or antennules, are uniramous, and the other two, antennae and mandibles, are biramous. Each limb bears a number of setae, and these from a functional point of view I divide into two types, swimming setae and feeding setae. The *swimming setae* are mostly long, continue more or less the direction of the limb-axis, and if feathered have very fine setules. They radiate out on each limb rather like the ribs of a fan, thus forming together a flattened plane. This plane is placed at right angles to the direction of beat of the limb. *Feeding setae* occur only on the antennae and mandibles. They all arise from the posterior or inner border of the limb, projecting approximately at right angles to it. They vary much in form, but are all shorter than the other setae, and mostly carry fairly stout setules. Unlike the swimming setae they are not arranged in any one plane.

The *antennule* (fig. 1, *Ant.* 1) is almost round in section, and carries eight swimming setae. Four of these are on the posterior border of the limb and four arise from the tip. So far as I could find, only the second, third, and sixth setae are feathered.

The *antenna* (figs. 1 & 3, *Ant.* 2) has a massive, rather square protopodite, slightly flattened vertically. The plane of this flattening is continued and increased by the way in which the exopodite and endopodite lie one above the other and by the plane of swimming setae. The exopodite, which lies dorsally when the limb is extended to the side, bears along the outer border a regular fringe of long setules (fig. 3), of use, perhaps, in increasing the breadth of the limb and so its resistance to the water. Distally there are seven swimming setae, of which only the second, third, and fourth appear feathered. On the endopodite there are distally five swimming setae, two a short distance back on the posterior border, and three at the tip. Of these only the first, fourth, and fifth are feathered. Proximally the endopodite bears two well-feathered feeding setae. Still nearer the base, probably to be considered as on the protopodite, are three more feeding setae—two very fine and unfeathered, and one very stout and feathered. Definitely arising from the protopodite is a large thick process, which extends under the labrum and ends in sharp prongs and spinules (fig. 4 c). This I call the antennal jaw process.

The *mandibles* (figs. 1 & 3, *Mnd.*) resemble the antennae in general shape and their armature of setae. The thick base is slightly flattened vertically, but to a less degree than that of the antennae. The plane of flattening is again continued by the exopodite and endopodite and by the plane of swimming setae. The exopodite bears at its tip four of these setae, all of which are feathered; the outer one is particularly strong, and has setules on one side only. On the endopodite there are five swimming setae, also all at the tip, but none feathered except the first, which from its position and peculiar type of feathering is probably to some extent also a feeding seta. More proximally, the endopodite bears five feeding setae, differing greatly in thickness and each

with its own characteristic type of feathering. Between the second and third of these is a short row of long setules (fig. 1). On the protopodite is a single feeding seta, short and thick, and sparsely feathered.

THE LIMB MOVEMENTS.

The animal swims continuously, only occasionally stopping on encountering an obstacle. It swims usually on the back, but may also swim dorsal side uppermost. All three pairs of limbs beat in a regular metachronal rhythm, the mandibles striking first and being immediately followed by the antennae and then the antennules. So far as can be judged by eye, the phase difference in each case is about one-sixth of a half beat.

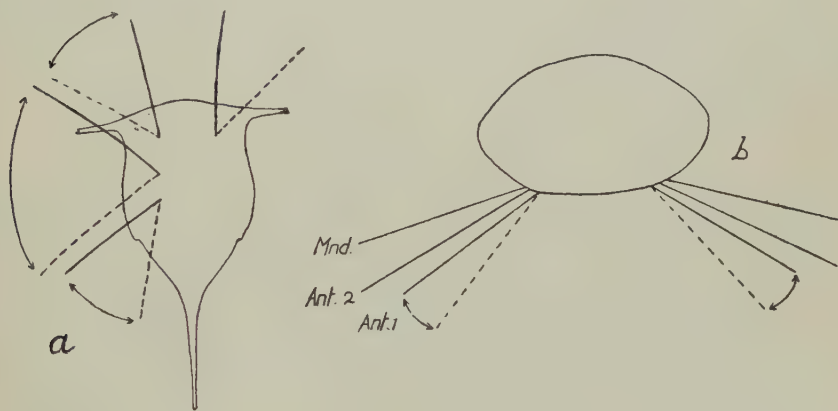


FIG. 2.—*a*, diagram to show approximate length of beat of each of the limbs; *b*, diagram to show approximate inclination of each of the limbs to the body as seen in end-on view. For the antennules the broken line represents the position at the end of the back-stroke, the continuous line the position at the beginning of this stroke.

The approximate length of beat for each limb is illustrated diagrammatically in fig. 2 *a*. Throughout the beat all three pairs of limbs project at an angle ventro-laterally from the body, the antennules stretching most ventrally, the mandibles least so (fig. 2 *b*). While the antennae and mandibles beat back and forwards at a constant angle, the antennules come down more ventrally during the back-stroke.

Each limb, with its plane of swimming setae, is slightly concave posteriorly. There is no change in this curvature during a beat, except in the antennae, which momentarily straighten a little just at the commencement of the back-stroke.

During each stroke the antenna turns on its axis. Thus at the beginning of a back-stroke the endopodite is in front of the exopodite, while at the end of the stroke the endopodite is behind (postero-median to) the exopodite. Only at the mid-stroke position is the exopodite vertically dorsal to the endopodite. Or, in other words, the flattened plane of the limb is truly vertical only in the middle of the stroke. It is inclined postero-dorsally (or antero-ventrally) in front of this position, and antero-dorsally (or postero-ventrally) behind it.

One effect of this action is that the medianly-directed feeding setae along the endopodite and protopodite beat more markedly in towards the body than would otherwise be the case. It also means that on the fore-stroke a pumping action between the limb and the body is enhanced. The flattening of the limb increases both the swimming effect of the back-stroke and this suction on the fore-stroke.

The mandibles show a similar turning on the axis, but to a less degree. While the flattened plane of the limb is inclined postero-dorsally in the anterior position (as with the antennae), when the limb beats back this plane becomes vertical only at the very end of the stroke.

CURRENTS PRODUCED BY THE LIMB MOVEMENTS.

The actual course of particles in the surrounding water is extremely difficult to observe for a *Balanus* nauplius. The animal is constantly moving forwards at what appears under the microscope to be a considerable speed, and there is no way of holding it still without interfering with the normal movements. But our knowledge of the limb movements suggests certain deductions, and, so far as it is possible to check these by eye, they are confirmed. The course of events thus determined is as follows :—

During the back-stroke, on each side a swirl is created, particularly by the antennae, and by this particles from in front and the sides are swept back and in towards the body. Those coming from in front may actually pass between the mandibles and so within reach of their feeding setae. But since they must pass under (or, if the animal is on its back, over) the large projecting labrum, probably most will lie too ventrally to be caught. It is probably in the fore-stroke that particles are drawn closer to the ventral surface of the body.

Since the limbs all project at different angles from the body, there can be very little suction between successive limbs. But as a limb moves forward it must tend to suck particles forward. Further, as the mandibles and antennae move forward each must produce a suction between itself and the body, and this is enhanced by the rotation of the limb already described. Thus particles lying just behind a nauplius, swept there in the back-stroke, during the fore-stroke are sucked forwards along the ventral surface of the animal. The antennae are still exerting this forward suction when the mandibles start to beat back, the feeding setae of the latter thus closing in on the particles

and knocking them forwards towards the mouth. Immediately afterwards the antennae also beat back and in, and their feeding setae must act similarly to those of the mandibles.

THE FEEDING STRUCTURES.

There is no completely effective mechanism for retaining the particles and moving them towards the mouth. Clearly a certain number must be lost.

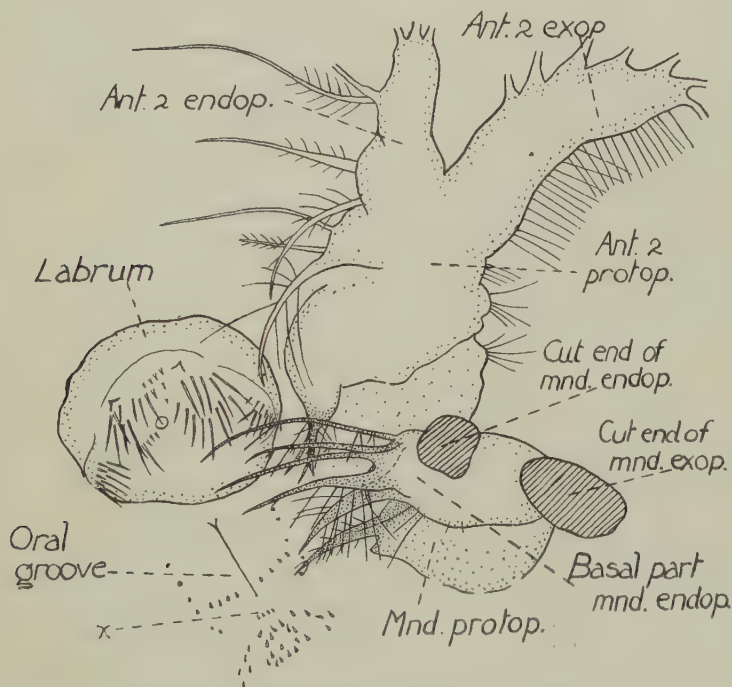


FIG. 3.—Antennae and mandibles in a forward position, as seen in a posterior view of a second stage nauplius. Only the basal parts of the antennal swimming setae are shown, and the mandibular exopodite and distal part of the endopodite are represented as cut off. The row of four body spinules marked 'x' serves as a landmark which can also be found in figs. 4 a and 4 c.

But, nevertheless, setae and setules are all arranged to favour retention and forward transport of the particles. Setules on the feeding setae, especially of the mandibles, all point in towards the body (fig. 3). The row of setules on the proximal half of the mandibular endopodite (fig. 1) also point medially. On the ventral surface of the body is a complicated pattern of spinules which all tend to point towards the mouth (fig. 4 a). Long setules on the end of the labrum point in and towards the middle line (figs. 3 & 4 b). Under the labrum

two longitudinal ridges flank a median groove which leads to the mouth, each carrying numerous very fine setules which all point medianly (figs. 4 *b* & 4 *c*).

As the mandibles and antennae beat back particles thus tend to be kept in the middle line, and they are pushed forwards under the labrum by the feeding setae. They are finally pushed into the mouth by the prongs on the antennal jaw processes, the most anterior of which, at the end of the back-stroke, reach actually to the mouth.

Cannon (1924) has suggested for the nauplius of *Estheria* that food is entangled by a labral gland secretion. It is possible that this suggestion is

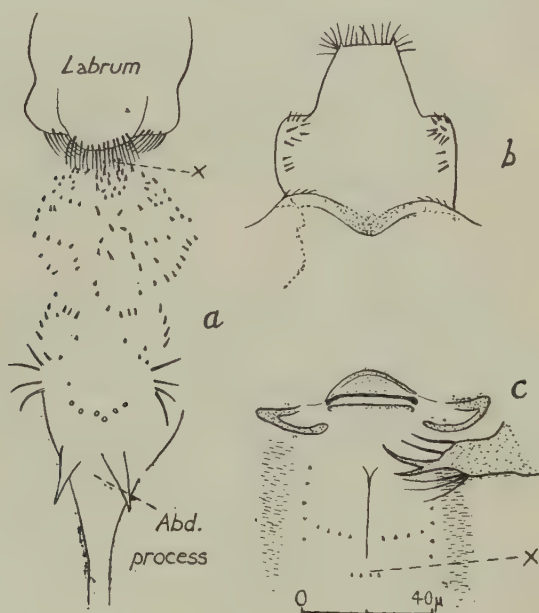


FIG. 4.—*a*, body spinules, second stage nauplius; *b*, labrum and the oral groove as seen in a second stage nauplius from a dorso-posterior position, the oral groove thus appears as though in transverse section; *c*, ventral view oral groove and mouth, with one antennal jaw process shown in position near the end of the back-stroke of the limb, labrum omitted.

true also for the nauplius of *Balanus*, in which these glands are well developed with a large duct opening at the tip of the labrum. But though I tried a number of intra-vitam stains I was unable to find the nature of the secretion or to demonstrate its presence outside the glands. Groom (1894-95), however, reports having seen it exuding from the glands as beads of clear liquid. This might conceivably be of a mucoid or sticky nature. But it should be noted that there is no structure suitable for brushing the secretion from the tip of the labrum on to the food,

THE TYPE AND SIZE OF FOOD.

As recently as 1927 the statement appeared that cirripede nauplii do not feed but live on a store of yolk (Krüger, 1927). For *Balanus perforatus* this statement is clearly untrue, if only because of the marked increase in size which occurs at each moult (cf. Groom, 1894-95). For the *Sacculina* nauplius, which does not feed, Delage (1884) has noted a decrease in size with successive moults.

Most workers, however, have recognized that typical cirripede nauplii do feed, and Lang (in 1878) for *Balanus perforatus* had already recognized and described the feeding setae as such.

The feeding of a *Balanus* nauplius is quite automatic, any type of particle below a certain size being accepted. To find the maximum size which can be taken I used a suspension of starch grains, the diameter of which varied



FIG. 5.—Types of food taken by the second stage nauplius. *a*, portion of *Prasinocladus lubricus* forma *subsalsa* Zimmermann; *b*, a cell of this alga seen in a nauplius stomach; *c*, diatoms seen in nauplii stomachs and all recognized in the surrounding water.

from 4-9 μ . Only those from 4-6 μ were found in the nauplius gut, so that it is evident that no particle over 6 μ in diameter can be taken through the mouth*.

The same rule is found to apply when diatoms are used instead of starch. Feeding on a phytoplankton mixture the nauplius can swallow all diatoms of 6 μ or less in diameter, but none larger. The length is not so important, for diatoms up to 25 μ long are frequently taken.

The structure of the mouth is difficult to make out. But it appears to be a transverse slit situated at the anterior end of the oral groove, and surrounded by chitinous thickenings (fig. 4 c). The slit is about 25 μ long, so that presumably it can be opened only 6 μ wide.

* Perhaps this is why Groom (1894) was unable to get his nauplii to feed on starch—he may have used too coarse a variety.

Besides small diatoms, protozoa and green algae may form part of the food (fig. 5). In one case where the guts of the nauplii were bright green the only possible source of this colour * was a small flagellate of 2-3 μ , very common in the surrounding water. In other cases a paler green colour came from the cells of a filamentous green alga, *Prasinocladus lubricus* forma *subsalsa* Zimmermann. This grew well in many of the cultures and was much fed upon by the nauplii. The cells were swallowed whole and individually, as many as ten still undigested cells being counted in one gut. In the surrounding water I never observed cells separated from their filaments. It thus seems possible that the animal can bite or pull the cells apart, for which I think only the antennal jaw processes could be used. Since the cells are swallowed whole (as with diatoms also) there is no true mastication, and, indeed, the prongs on the antennal jaw processes are quite unsuited for this.

Groom (1894) thought that the food consisted both of small particles and of bodies of some size which were held by the feeding setae and masticated by the jaw processes. But, as I have shown, there is no true mastication, and no one has ever observed a nauplius ceasing its movements while holding a body between its limbs. I think it must be clear that feeding on anything larger than an alga such as *Prasinocladus* is quite impossible. Groom's further suggestion that the labral glands produce a poisonous secretion, used for paralysing large prey, may thus also be discounted. It may be added that the small simple eye is not such as would be expected in an active predaceous animal.

With regard to feeding on small particles, Groom fully recognized the importance of the various setules on the feeding setae, labrum, and body. But he believed that they served to keep the particles within the sphere of attraction of the oesophagus, the swallowing movements of which sucked water and particles from presumably as far back as the posterior body spinules. Such a suggestion implies the swallowing of a vast amount of sea water, and for this reason I cannot admit it to be true. Moreover, as will be shown presently, the first-stage nauplius makes constant swallowing movements with its oesophagus, yet scarcely ever takes up any particles.

THE RATE AND EFFICIENCY OF FEEDING.

The rate of feeding is very rapid. In a carmine suspension particles can be seen in the gut after two and a half minutes, and after fifteen minutes the gut is full. Attempts to gauge the efficiency by using different concentrations of carmine were not successful. Those animals in the higher concentrations seemed to show carmine in the gut a little before the others, but the time

* Groom (1894) suggested that the frequent green colour of the gut might be due to an alteration in the colour of the yolk. But this is not so, for the colour of the gut varies wholly in accordance with the type of food particle given.

taken to fill the gut seemed about the same in all. It looks as though the mechanism for collecting particles is very efficient, but that there is a limiting factor in the rate of ingestion by the mouth.

The time which food remains in the gut depends partly on the rate of feeding. In a carmine suspension the contents of a full gut are almost entirely replaced by carmine in fifteen minutes. But in filtered sea water a gut full of natural food remains so for many hours, and is only partly empty after two days.

THE FIRST STAGE.

The first stage nauplius of *Balanus perforatus* (fig. 6) is in a very much simpler condition than are the second and later stages. The stage is at once recog-

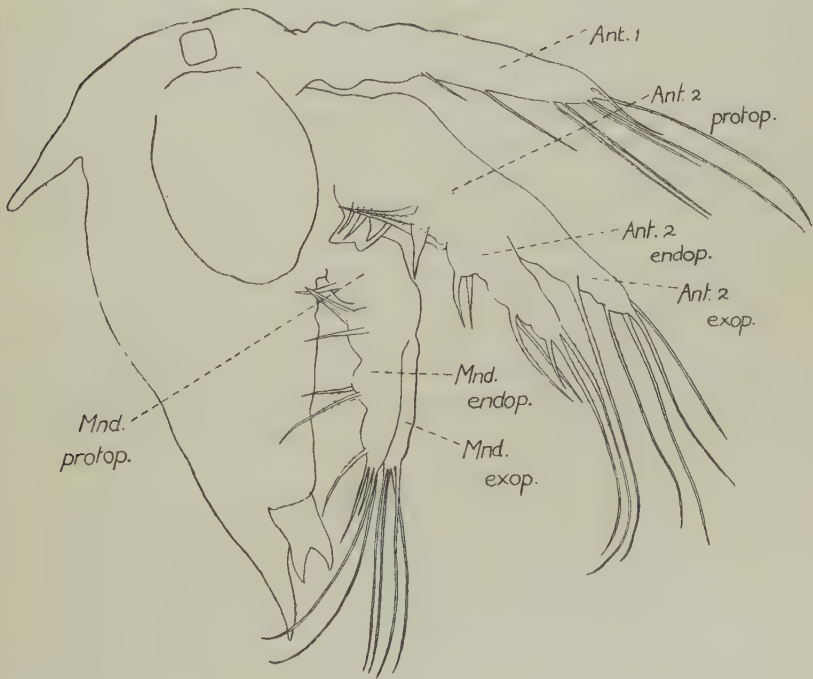


FIG. 6.—Ventral view of first stage nauplius of *Balanus perforatus*.
Limbs of right side not shown.

nizable by the considerably faster limb-beat, accompanied by a faster rate of swimming. This may be correlated with the shorter limbs and swimming setae, which offer less resistance to the water. The setae are all unfeathered, though some show slight serrations probably caused by developing setules underneath.

In spite of the swimming activity, the animal does not feed. I attribute this to the poor development of the feeding structures. The gut is fully formed on hatching, and peristalsis in the oesophagus starts at once. Moreover, the mouth is apparently open, since I found one individual which had taken up a few grains of carmine. But the structures for collecting food and carrying it to the mouth are all rudimentary. The feeding setae are short and without setules; there are no body spinules and no labral setules, though underlying rudiments of both may be seen shortly before moulting; and, in particular, the antennal jaw processes, ending in two blunt lobes, are much too short to reach to the mouth. Their cuticle is very thin, and underneath the sharp prongs of the next stage can be clearly seen. Granted that the mouth is open, the extreme rarity with which in this stage particles ever find their way to the gut is good evidence of the importance of the feeding setae and setules in the later stages.

According to Groom (1894) about 15–16 endoderm yolk cells surround the lumen of the mid-gut of the newly hatched nauplius. There is thus this possible source of nourishment while the animal is unable to take up food from outside.

Of morphological interest is the absence in the first stage of four setae found in the succeeding stage. The setae missing are a feeding seta on the mandibular endopodite, another feeding seta on the antennal protopodite, and two swimming setae on the antennal exopodite. Also absent in the first stage, but appearing in the second, are the frontal filaments. If these organs are olfactory this is perhaps as might be expected.

It is possible that the first stage is not set free in nature. Nilsson-Cantell mentions the same possibility for *Verruca strömia*, pointing out that until a stage is found in the plankton its emission in the aquarium cannot be accepted as proof of the same condition in nature. I never observed any first stage *Balanus perforatus* in the plankton. But this is not surprising, since moulting occurs so soon.

The first moult involves not only a greatly increased complexity, but also a considerable increase in size. In particular, the new cuticle is stretched longitudinally. For this reason the body spinule pattern, seen under the old cuticle shortly before moulting, appears greatly compressed.

An interesting point arises from the rapidity with which the limbs and setae become clogged in a carmine or other suspension. This is very much greater in the first than in later stages. The difference may partly be due to the higher rate of limb-beat, but I suggest that it is chiefly because of the absence of cleaning structures. In a carmine suspension the animal frequently stops to draw its antennae and mandibles over the caudal region of the body. Here the second stage nauplius has several structures probably of use in cleaning: both the caudal and abdominal processes are long and strongly serrated; at the base of the abdominal process is a pair of large spines; and further forward there is a group of four long setules on each side. In the first stage

the caudal and abdominal processes are short and unserrated; there are no spines and no setules. Consequently the animal is unable to clean its limbs effectively.

SUMMARY.

1. The rearing of *Balanus* nauplii in the laboratory and the stage at which hatching occurs are discussed.

2. The external morphology of the second stage nauplius of *Balanus perforatus* is described. The setae on the limbs I divide into two types—swimming setae and feeding setae.

3. The limbs beat in a metachronal rhythm. During the back-stroke particles are swept backwards and inwards, converging from each side just behind the body. From here they are sucked forward along the ventral surface during the fore-stroke of the mandibles and antennae.

4. They are retained in the region behind the labrum by the feeding setae and their setules, by spinules on the ventral surface of the body, and by setules on the tip of the labrum.

5. As the limbs beat back the feeding setae push the particles towards the mouth. A groove under the labrum leads to the mouth itself, into which the particles are pushed by prongs on the antennal jaw processes.

6. Feeding is rapid and not selective. But particles over 6μ in diameter cannot be swallowed, though diatoms 25μ long are freely taken. It appears that single cells may be torn from filamentous algae and then swallowed. But there is never any true mastication, and larger bodies do not form part of the food.

7. The first stage nauplius does not feed. The mouth is apparently open, but the feeding structures are very rudimentary, and particles can thus reach the mouth only by accident.

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The seasons in a tropical rain-forest (New Hebrides).—Part 1. Meteorology.
By JOHN R. BAKER, M.A., D.Phil., and T. H. HARRISON. (Communicated
by Professor E. S. GOODRICH, F.R.S., F.L.S.)

(With 8 Text-figures)

[Read 7 November 1935]

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INTRODUCTION.

The studies described in this paper will be followed by papers upon seasonal phenomena in plants and animals in a tropical rain-forest. The whole investigation was the main corporate activity of the Oxford University Expedition to the New Hebrides, 1933-4. It was planned and directed by one of us (J. R. B.), but the whole expedition co-operated in carrying out the work. For simplicity of reference, we are limiting the names of the authors of each paper to two or three, but we wish to make it clear that all six members of the expedition did their shares of the meteorological observations, and we wish to acknowledge the help of the others (Mr. A. J. Marshall, Mr. T. F. Bird, Miss I. Baker, and Mrs. Z. Baker).

The expedition was made under the auspices of the Oxford University Exploration Club, and its meteorological and biological work was financed partly by grants from the Royal Society, the Percy Sladen Memorial Fund,

the University of Oxford, and New College, Oxford. When planning the expedition we had the great advantage of receiving very helpful advice on meteorology from Mr. W. G. Kendrew and Professor P. A. Buxton. Among the many people who helped us in the islands we must particularly mention the British and French Resident Commissioners, the Rev. W. Anderson, Mr. T. R. ff. Salisbury, and Mr. W. Robertson. Many natives with accurate knowledge of natural history gave willing help. The results of the expedition are being worked out in the Department of Zoology and Comparative Anatomy at Oxford by permission of Prof. E. S. Goodrich, F.R.S. A general account of the expedition is given elsewhere (Baker, 1935 *a*).

The object of the whole investigation was to find how the reproduction of animals and plants is carried on in a climate which varies little during the course of the year. The investigation was mainly zoological, the plants being studied rather as a side-line. In the northern New Hebrides, in the Pacific Ocean, there is little seasonal change of climate, and the vertebrate fauna is sufficiently varied for a general study of the problem to be possible. The main problems confronting us were these:—(1) What seasonal changes of climate occur? (2) Do animals and plants have distinct breeding and flowering seasons? (3) Can the breeding and flowering seasons, if they exist, be correlated with any particular meteorological phenomena? (4) Is any teleological explanation of special breeding and flowering seasons in such a climate possible? In this paper only the first of these problems is considered.

The meteorological observations were made at Hog Harbour, which is situated in latitude 15° 15' S. on the east coast of Espiritu Santo, the largest island of the New Hebrides (see map, fig. 1). The island is about 75 miles long and 45 miles wide. At Hog Harbour there live five white people and between 150 and 200 natives. There are a coconut plantation and native gardens. The village is only connected with other parts of the island by narrow tortuous native paths which run through the luxuriant rain-forest. This covers nearly the whole island except part of the south and south-east coasts, where there is a number of plantations owned by whites. Native villages, with their gardens, are scattered here and there throughout the island, but occupy a very small total area. In some respects it would have been better to make the base away from all human habitation, but the practical difficulty of getting all the equipment and food of an expedition to such a place would be too great, nor could one afford to dispense with the help of native collectors when hundreds of specimens were required monthly. Indeed, the fact that one of us was already well known to the natives of Hog Harbour influenced our choice of a base.

Meteorological observations were carried out by the expedition at Hog Harbour during a period of a year and a day, from 5 September 1933 to 5 September 1934 inclusive. In considering the effect of the climate on breeding seasons, one must consider not only the climate during the special period in which the biological observations were made, but also the usual climate

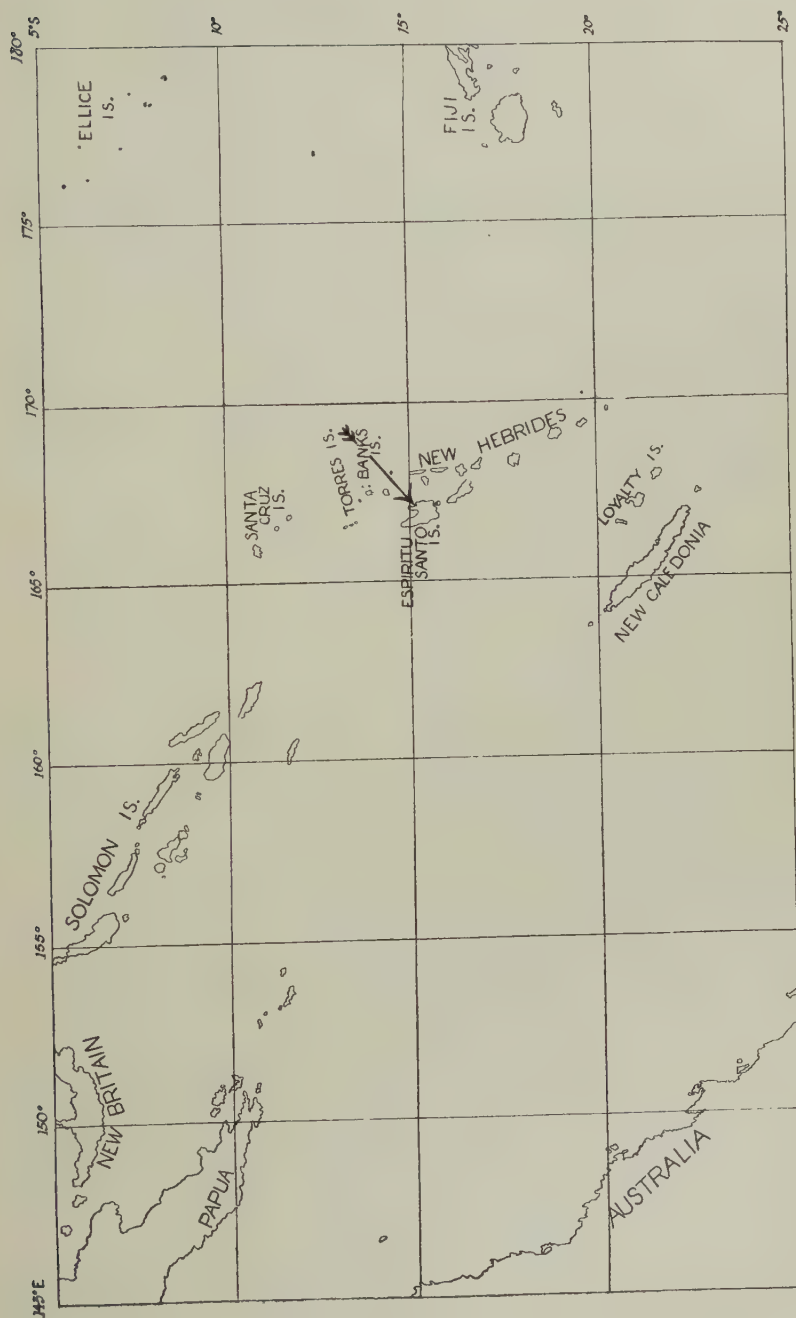


FIG. 1.—Map of part of the western Pacific Ocean.
The arrow shows the position of Hog Harbour.

of the region studied, to which the organisms may be regarded as having adapted themselves. It is convenient to consider the usual climate of Hog Harbour, and its climate during 1933-4, separately.

THE USUAL CLIMATE OF HOG HARBOUR.

Mr. T. O. Thomas, formerly owner of the coconut plantation at Hog Harbour, kept records of the rainfall over a period of 23 years (1904-26), and has kindly put his figures at our disposal. As regards temperature, we have figures of daily maxima and minima for three periods of twelve months, namely, the observations of Mr. Thomas during 1926, of Mr. Thomas and one of us during 1927, and of this expedition during 1933-4. It must be mentioned that in 1926 and 1927 the temperature was taken in a shelter of palm-leaf thatch. This shelter, being open on all sides but giving excellent insulation from the direct rays of the sun, gave reliable readings. During 1933-4 the observations were made in a Stevenson screen. The usual climate of Hog Harbour, as deduced from these observations, is shown in tabular form below. The mean temperature of each month is the mean of the daily maxima and minima:—

	Jan.	Feb.	Mar.	Apr.	May.	June.
Mean temp., °C.	27.3	26.9	27.0	27.0	26.4	25.8
Mean daily rainfall (mm.)	11.44	11.54	10.31	11.20	10.98	5.75
	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Mean temp., °C.	24.9	25.2	25.4	25.9	26.7	27.2
Mean daily rainfall (mm.)	5.70	4.59	5.53	6.24	10.55	8.55

These figures are represented graphically by means of a hythergraph in fig. 2 B. The hythergraph is made by plotting the mean temperature of each month as ordinate, and the mean daily rainfall of each month as abscissa, and joining the points so obtained in the order of the sequence of the months. The general features of the climate of any place are well shown in this way.

There is little variation in temperature during the year, the hottest month (January) being only 2°.4 C. (4°.3 F.) hotter than the coolest (July). There is no dry season, for during the least wet month there is about twice as much rainfall as in the wettest month over most of England. Five consecutive months in the year (June, July, August, September, and October) are, however, considerably less wet, as well as a little cooler, than the rest. The wettest month (February) receives on the average about two and a half times as much rain as the least wet (August).

COMPARISON OF THE CLIMATE OF HOG HARBOUR WITH THAT OF OTHER TROPICAL REGIONS.

The whole of this investigation was planned and undertaken because the New Hebrides have an unusual climate which presents special biological problems. It is necessary, first, to show how unusual the climate is.

In temperate regions there is often little tendency for the rainfall to be seasonal, and the seasons are demarcated by great changes in temperature. In the tropics the seasonal changes in temperature are small, but there are usually great seasonal changes in rainfall. There appears to be no land surface in the tropics in which there is no seasonal periodicity in rainfall. In order to obtain a general view of this subject, an analysis was made of the figures for all the 113 tropical rainfall recording stations, whose mean rainfalls for ten or more years are given in 'World Weather Records' (Simpson and others, 1934). The number of times that the wettest month was wetter than

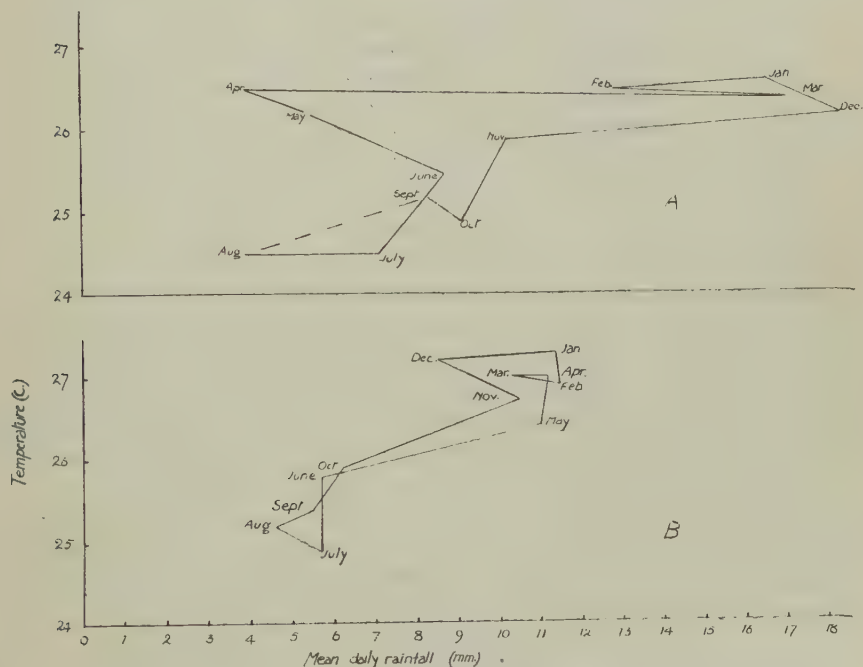


Fig. 2.—Hythergraphs showing the climate of Hog Harbour during 1933-4 (A) and over a period of years (B).

the driest month was found for each of the stations. This was done by simply dividing the amount of rainfall (millimetres or inches) in the driest month into the amount in the wettest month. It was not thought necessary to make a correction for the varying number of days in the months. The resulting figure may be called the 'seasonal index' of rainfall. The seasonal index for Hog Harbour is 2.5. Among all the 113 stations, distributed over the whole of the tropics, that are mentioned in 'World Weather Records', only three have a lower seasonal index than this. These three are Pontianak (Borneo) and San Juan (Porto Rico), which both have a seasonal index of 2.2, and

Padang (Sumatra) with an index of 2·4. Only nineteen of the stations have an index less than 5·0. Of these nineteen, eight are in the East Indies, three in the West Indies, three in the Pacific, three in South America, one in the Atlantic, and one in Africa.

The following table shows how rare it is for a tropical country to have a low seasonal index of rainfall :—

<i>Seasonal Index</i> (i.e. no. of times the wettest month is wetter than the driest).	No. of tropical stations whose rainfall is recorded in ' World Weather Records '.
0-2·5	3
2·6-5·0	16
5·1-10·0	24
10·1-20·0	20
20·1-40·0	13
40·1-80·0	9
More than 80·0	28
	<hr/> 113

It might be thought that the somewhat uneven distribution of rainfall-recording stations materially decreases the value of the preceding remarks, but this is not so. In the above analysis Africa is only represented by one station with an index less than 5, and therefore it is worth while to study tropical Africa a little more closely. In his book on the climate of Africa, Knox (1911) gives a large diagram of the seasonal changes throughout the tropical regions of the country. 30 of the 33 stations which he mentions have less than 25 mm. of rain in the driest month and may therefore be regarded as having a regular dry season. Of the other three stations, the least seasonal has an index of 4·4. It might be thought that parts of the Belgian Congo would have relatively unvarying climates, but Gasthuys (1924) has shown that all the seven stations which he studied are markedly seasonal in rainfall. Five of the stations have a regular dry season, while at the other two the distribution of rainfall is distinctly seasonal, although there is not any prolonged absence of rain.

It has already been mentioned that the mean temperature of the hottest month at Hog Harbour is, on the average of three years, 2°·4 C. (4°·3 F.) greater than that of the coolest month. Although this is a small difference, it is not an exceptionally small one for a tropical country. If we take all the stations mentioned above whose seasonal index of rainfall is less than 5·0 and whose temperature changes are known, we find that the differences between the hottest and the coolest months, in degrees Centigrade, are as follows :—0·9, 1·3, 1·4, 1·4, 1·8, 2·7, 3·1, 3·2, 3·4, 4·1, and 4·9. At Hog Harbour the surrounding ocean ensures a relatively small seasonal change in temperature, despite the considerable distance (15° 15') from the equator,

It must not be imagined that such an unseasonal climate as that of the New Hebrides is found in all regions of the world where a typical rain-forest is developed. Thus Allee (1926), in his study of the rain-forest of Panama, showed that, although the temperature varies little during the year, there is a very great annual cycle in rainfall, which changes almost regularly from a minimum of about 1.1 inch in March to 16.4 inches in November. The mean relative humidity is low (about 75 per cent.) in March and high (about 90 per cent.) in November. There is, further, a regular annual cycle in cloudiness. Kenoyer (1929) also speaks of the 'marked seasonal distribution' of rainfall in this rain-forest. McLean, again, in his study of the climate of the tropical rain-forest (1919), speaks of the 'decided periodicity' of that of South Brazil in temperature, rainfall, relative humidity, and number of clear days. He states that the cool months are regularly dry and the hot months wet.

It is clear that the climate of Hog Harbour is an unusually unvarying one, even for a region where a rain-forest is developed. It remains to enquire what parts of the world present an equally or more unvarying climate. The little island of Nauru, in the Gilbert group in the Pacific, may have the most unseasonal climate of any land-surface in the world, for the mean temperature of the hottest month is said to be only $0^{\circ}6$ C. greater than that of the coolest (Kendrew, 1930), and the seasonal index of the rainfall works out at only about 2.5, while the situation, within half a degree of the equator, ensures that the length of day scarcely varies. Jaluit Island, in the Marshall group, has an even smaller range of temperature ($0^{\circ}4$ C.) and a lower seasonal index of rainfall (about 1.8), but the greater distance from the equator (nearly 6° N.) makes the length of day slightly variable. Nevertheless, small isolated islands such as these would be unsuited, from the poorness of their fauna, for any large investigation of the effect of an unseasonal climate on breeding seasons. Certain places in the East Indies would perhaps be even better suited for a study of this sort than the northern New Hebrides, and it is hoped to visit one of them in this connexion. In particular, the vicinities of Pontianak in Borneo and Padang in Sumatra seem almost ideal. The former is almost exactly on the equator and the latter less than 1° away from it, so that the seasonal temperature change must be very small, and that in length of day almost non-existent. The seasonal indices of rainfall are 2.2 and 2.4 respectively, as compared with 2.5 at Hog Harbour. Pontianak, with 2.2, has the smallest seasonal index of all the 113 tropical stations analysed above. Although there is a number of places in the East Indies with an unusually unseasonal climate, one must avoid the error of supposing that these islands as a whole possess such a climate. In addition to the eight East Indian stations already mentioned, in which the seasonal index of rainfall is less than 5.0, there are six others with indices of 5.9, 7.1, 8.9, 11.9, 35.5, and 262, and one in which there was no rainfall at all in ten successive Septembers, but an average of 265 mm. in the January of the same years. The tendency towards great seasonal changes in rainfall culminates in the monsoon-forest of East Java, where teak and the

great majority of the other trees are regularly deciduous during the dry season (Schimper, 1903).

The climate of Hog Harbour may now be compared with that of other places in its vicinity. Probably the other islands of the northern New Hebrides and Banks Islands, nearly all of which we have visited, have an essentially similar climate, though along the west coast of Espiritu Santo there is a dry period in the year. The southern New Hebrides and New Caledonia have a distinctly seasonal climate as regards both temperature and rainfall. Fiji (Suva) has a climate similar in general to that of Hog Harbour, with a slightly higher seasonal index of rainfall and a greater temperature difference between the hottest and the coolest months ($4^{\circ}\cdot 1$ C. instead of $2^{\circ}\cdot 4$ C.). Samoa (Apia) has a smaller temperature difference ($1^{\circ}\cdot 1$), but a much greater seasonal index of rainfall (5.6) than Hog Harbour. The Solomon Islands, to the north-west, resemble the New Hebrides. Guppy (1887) states that the meteorological data at his disposal 'do not warrant the conclusion that one season is wetter than another'. This statement, however, does not seem to be fully borne out by figures which he gives at the end of his book; but it is clear that, as at Hog Harbour, there is no dry season. The more recent figures (Robson, 1933) from Tulagi show that there is about 3.3 times as much rain in the wettest month (February) as in the driest (December).

The conclusion to be drawn from this short survey of tropical climates is that there are few places in the world which are less seasonal than the vicinity of Hog Harbour. Over much the greater part of the tropics the seasons are as well marked by changes in rainfall as they are by changes in temperature in the temperate regions. Hog Harbour is therefore of particular interest to the student of seasonal biology.

THE CLIMATE OF HOG HARBOUR DURING 1933-4.

(1) *Methods.*

During the twelve months (September 1933 to August 1934) in which the breeding and flowering seasons were studied, daily records of climate were made. Two meteorological stations were set up, one in an area of several acres of cleared ground belonging to the Presbyterian Mission and the other in the rain-forest. These will be called the sunshine station and the forest station respectively.

The sunshine station was situated on almost level ground about a quarter of a mile from the sea and about 40 feet above sea-level. Care was taken to expose all instruments in accordance with the instructions given in 'The Meteorological Observer's Handbook' (Anonymous, 1926). A Stevenson screen was used for the exposure of maximum and minimum thermometers. The bulbs were more than three inches from the insides of the top, bottom, and sides of the screen. A grass minimum thermometer was exposed nightly. Rainfall was measured by an 8-inch rain-gauge, which was read daily at about

7.30 a.m. and the rain credited to the previous day. A Campbell-Stokes sunshine recorder was cemented into its true position. To the east the horizon was the sea and low-lying distant ground; to the west it was a nearly level cliff subtending at an angle of 14° to $15^{\circ} 30'$ above the horizontal. By the time that the sun began to be obscured by this cliff it had already lost, or almost lost, its power of burning sunshine-cards, and therefore the exposure of the sunshine recorder may be regarded as almost ideal. (Radiant heat was not measured, owing to the unfortunate breakage of the radiation integrator on the journey from England.) Ultra-violet light was measured by the acetone methylene blue method. The tubes were not exposed vertically, since that arrangement is particularly unsuitable in the tropics, where the sun passes directly overhead twice a year. They were held on a special frame, made by Mr. S. J. Baker (see Baker, 1934), which was rotated slightly each month, so as to keep them always approximately at right angles to the direct rays of the sun. We wish to acknowledge a great deal of help from Mr. S. J. Baker. A quartz tube and a glass tube were exposed at the same time, and the number of units of fading of the contents of the glass tube was subtracted from the number of units of fading in the quartz tube. The tubes had often to be refilled several times in one day, owing to the rapid fading of the colour. For this reason the measurement of ultra-violet light was confined to certain months, lest it should occupy an unjustifiable amount of the time of the expedition.

In conjunction with Mr. T. F. Bird we made a simple arrangement to find whether any large seasonal changes occurred in the duration of twilight. A large board was painted black, with a circular spot in white enamel paint, 10 cm. in diameter, in the middle of it. This board was erected vertically, facing west, in an open space, and a mark was made on the ground 20 metres to the west of it. On nights when there was no moon the observer stood or sat with his eyes level with the mark and recorded the time at which the white spot became no longer steadily visible. The size of the spot and the distance were so selected that the time when the white spot disappeared roughly corresponded with the subjective impressions of the members of the expedition as to the time when the twilight merged into darkness. It was found that the different members of the expedition agreed with one another within a few minutes in judging the moment of disappearance of the white spot.

A five-inch aneroid barometer was hung close to the sunshine station and read daily at 1.45 p.m. It was not checked against a mercury barometer after leaving England, and its readings may therefore be all slightly too high or all slightly too low; but it may be relied upon for seasonal changes of barometric pressure.

The rain-forest of the lowlands of Espiritu Santo is remarkably uniform, and it was not difficult to choose a place for the forest meteorological station which may be regarded as typical of most of it. The selected place is about a quarter of a mile from the sea and 55 feet above sea-level. Since scarcely

any direct sunlight filters through the dense foliage, it was not necessary to use a Stevenson screen. A simple screen with single louveres was attached to a tree at the standard height of a Stevenson screen. In this screen a maximum and a minimum thermometer and wet and dry bulb thermometers were exposed. The wet and dry bulb thermometers were read at 2 p.m. daily. The appropriate tables for still air were used in the calculation of relative humidity. An earth thermometer, whose bulb was situated 30 cm. below the surface of the ground, was read daily at 2 p.m. A katabatic thermometer was suspended from a wire running between two trees, at such a height that its bulb was one metre above the ground. The standard model, not the tropical model, was used, since it is a better indicator of the cooling power of the atmosphere on warm-blooded animals. Since the temperature in the forest never reached 95° F., there was never any necessity to substitute the tropical model. The katabatic thermometer was read once dry and once wet every day at approximately 2 p.m. An umbrella was held over the instrument when the readings were made in the rain. The instrument was always warmed up and allowed to cool once before the first reading was made. The time of cooling was measured by stop-watch. During the first two months two dry readings and two wet readings were made consecutively, but the results showed that this was a waste of time. The daily first readings of the dry instrument during the month of October averaged 100.7 seconds. The average of both readings for the same period was 101.1 seconds. The difference being negligible, the second reading was discontinued. In hot climates, especially in such situations as forests, in which draughts are seldom felt, repeated readings are unnecessary on account of the slowness of the cooling, which allows sufficient time for a fair sample of the conditions to exert their effect. A spherical-bulb Livingston atmometer (evaporimeter), with valve, was exposed among the vegetation of the forest, the middle of the bulb being 40 cm. above the ground. Evaporation being extremely slow, readings were made only at the end of each month. Distilled water was used. At the beginning of each month a new evaporimeter, with a bulb that had been cleaned and dried, was substituted. Dr. Livingston's directions were carefully followed throughout. The results are expressed as the number of c.c. evaporated in a given time, multiplied by the 'factor' inscribed on the bulb. The product is in 'Livingston units', which are not absolute units, but which are nevertheless the accepted measure for comparative purposes. (See Livingston, 1935.) The utmost care was taken not to disturb the undergrowth at the forest station more than was absolutely necessary to get at the instruments. The path to the station was intentionally made crooked, so as to avoid the possibility of a direct draught.

Most of the meteorological instruments used were made by Messrs. Casella, and we wish to acknowledge our satisfaction with them. Each thermometer except the grass minimum was tested shortly before or after the expedition, and all except one were found to have no error or negligible errors in the

relevant part of the scale. The exception was the ground thermometer (by another maker), which had a small error which is allowed for in the figures given in this paper.

(2) *General remarks.*

The daily readings were averaged monthly, and the climate for the year is shown in the Appendix in the form of monthly means.

Fig. 2 A is a hythergraph showing the general features of the climate during the year September 1933 to August 1934. The temperatures are the monthly means of the maxima and minima taken in the Stevenson screen at the sunshine station. It will be realised that a hythergraph showing a single year's climate will naturally tend to be less regular than one showing the mean climate of several years. The hythergraph shows that, as usual, the months of June, July, August, September, and October were less wet and slightly cooler than December, January, February, and March; but April and May, usually very wet months, were not nearly as wet as usual. Further, the total rainfall for the year was above the average. From 5 September 1933 to 4 September 1934, inclusive, the total rainfall was 3659 mm. (144.1 inches). During the period 1904–26 inclusive, the mean annual rainfall was 3106 mm. (122.3 inches).

(3) *Temperature (in the open and in the forest; on the grass and in the earth; the cooling power of the atmosphere).*

The temperatures under various conditions during 1933–4 are shown in fig. 3. (It is unfortunate that the breakage of a maximum thermometer resulted in no maxima being recorded in the Stevenson screen from the middle of May to the middle of July. Thus there are no figures for maxima in the sunshine station during June, and the figures on which the means for May and July are based are incomplete.) The general conclusions to be drawn from all the temperature records taken together are these. December to April was on the whole slightly hotter than the rest of the year. After April the temperature fell off and reached a minimum in August. Four of the six thermometers made August the coolest month, and the other two July. Thus there was a definite but slight seasonal change in temperature. The mean temperature in the screen in the open only varied by 2°·1 C. between the hottest and coolest months, about one-eighth of the variation at English stations during the same period. The minima in the forest were closely similar to the minima in the screen at the sunshine station, but the forest maxima were always much below the maxima in the screen. High temperatures were never reached in the forest. In April the mean maximum temperature was only 27°·6 C., and this was the month with the highest maxima in this situation. Under no circumstances, however, was the climate ever anything but warm. The lowest single reading of the minimum thermometer in the screen at the sunshine station was 17°·3 C. on 16 June. Even the grass minimum, fully exposed to the sky at night, never gave low readings. In August, the coolest

month, the mean minimum on the grass was $20^{\circ}2$ C. The earth attained its maximum temperature in April and its minimum in August.

The cooling power of the atmosphere, as determined by the kata-thermometer daily at approximately 2 p.m., is shown graphically in fig. 4. For comparison, readings were made also at Oxford during July 1934 and January 1935 in a strip of wood in the Oxford University Parks, composed mainly of sycamore-maple, elm, and yew. Two readings were made here daily of both wet and dry bulb kata-thermometer at 2 p.m. G.M.T., and the means are shown on the graph. The readings are joined by broken lines to aid the eye in making

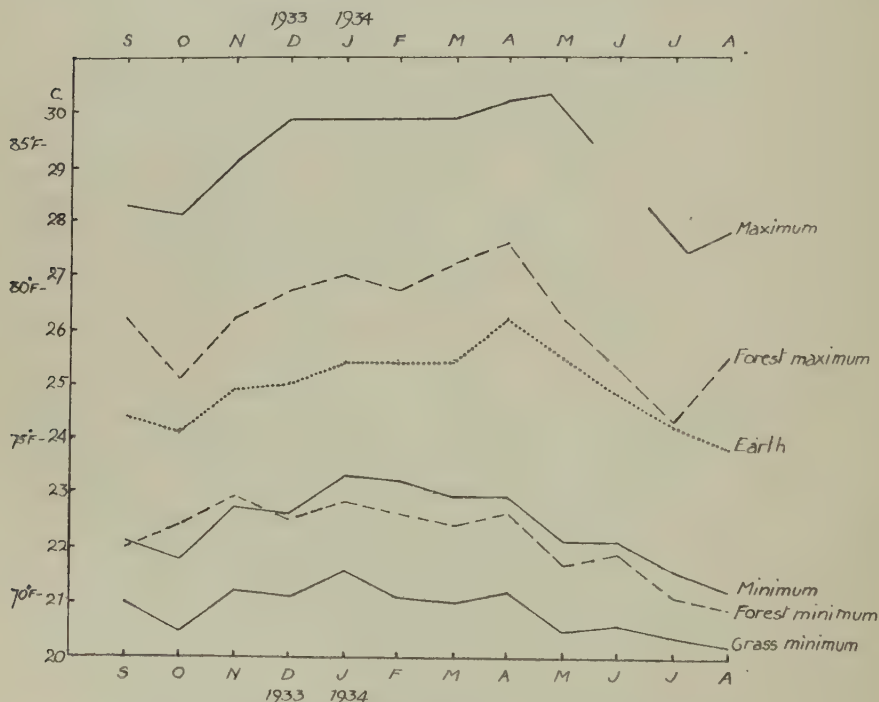


FIG. 3.—Monthly mean temperatures at Hog Harbour, 1933-4.

a comparison with the conditions at Hog Harbour. (Two or more readings daily at approximately the same time are necessary in a cool climate, in which the cooling time is short). It is immediately obvious that the cooling power of the atmosphere is very constant at Hog Harbour and varies widely at Oxford.

July 1934 was unusually hot at Oxford, and approached the coolest month at Hog Harbour in dry kata-thermometer readings; but the high humidity at Hog Harbour made a wide difference between the wet kata-thermometer readings at the two places, a difference that is exemplified by the failure of

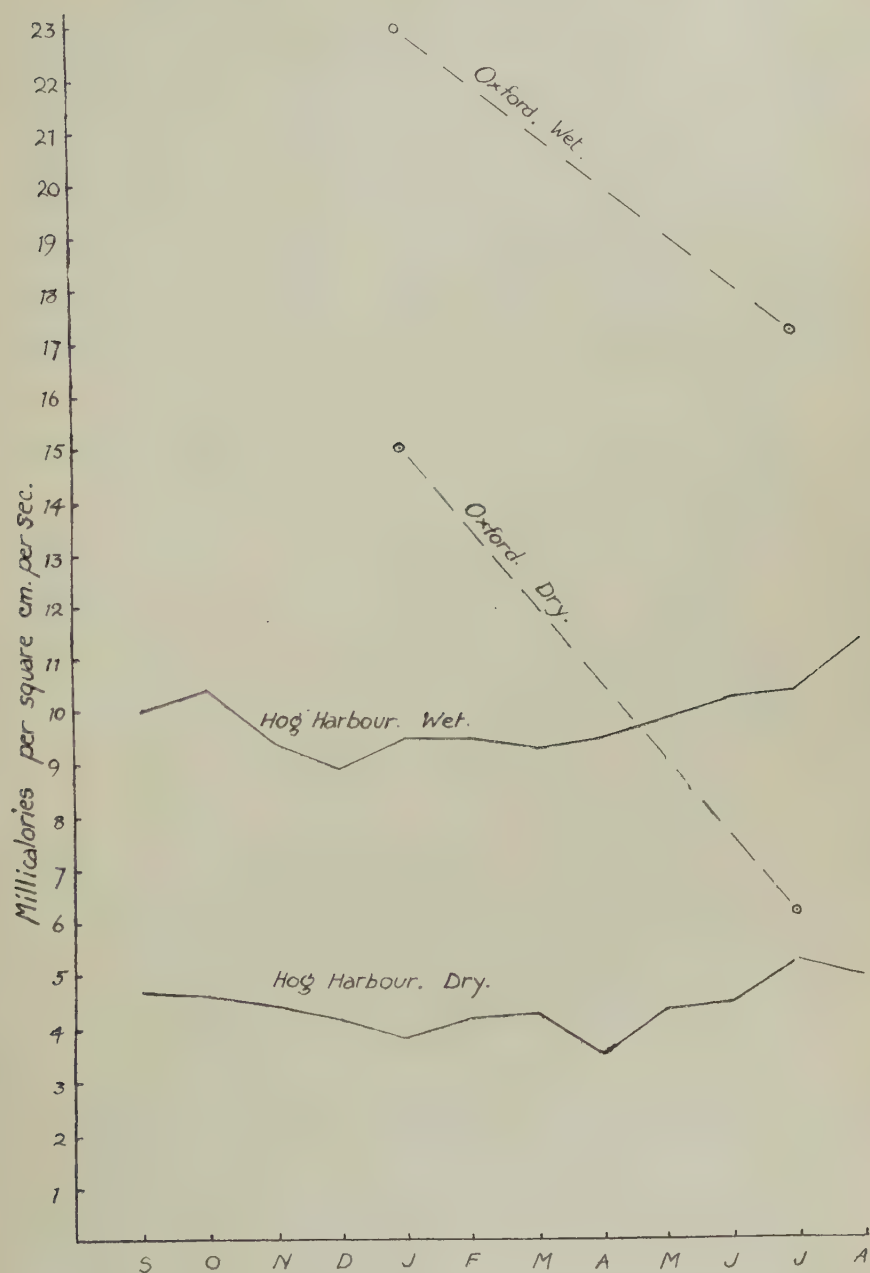


FIG. 4.—The mean cooling power of the atmosphere at Hog Harbour (1933-4) and at Oxford (1934-5).

one's sweat to evaporate at Hog Harbour. By both wet and dry kata-thermometer the coolest months are July and August. The trade winds, which blow steadily at that time, are probably partly responsible for the higher cooling powers of the atmosphere recorded in these months, though naturally only a little of their effect is felt in the forest. Buxton (1927) attributed the seasonal change that he found in kata-thermometer readings in Samoa mostly to variations in the amount of wind. His observations, however, were made on a verandah exposed to the wind.

During one week (19-25 December 1933, inclusive) repeated readings of the kata-thermometer were made throughout the day and night at the forest station, in order to find the diurnal variation. We wish to acknowledge the special co-operation of Miss I. Baker and Mr. T. F. Bird in this work. Sixteen

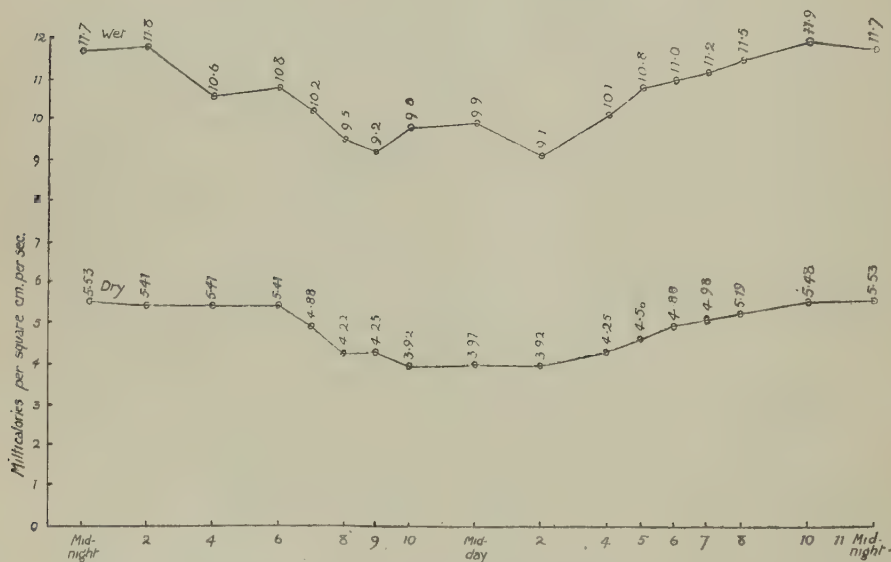


FIG. 5.—The mean cooling power of the atmosphere in the forest at Hog Harbour, 19-25 Dec. 1933, inclusive.

readings of dry and wet bulb kata-thermometer were made daily, at 2, 4, 6, 8, 9, and 10 a.m., midday, 2, 4, 5, 6, 7, 8, and 10 p.m., and midnight. The means of the seven days are shown in the graph (fig. 5). 2 p.m., the time of the daily reading, is the time at which the cooling power of the atmosphere is at its lowest. The cooling power increases smoothly thereafter and reaches its highest point, or a figure very close to it, at 10 p.m. The dry kata-thermometer gives almost the same reading from 10 p.m. throughout the night until 6 a.m., while the wet one, being especially sensitive to draughts, is less steady. By 8 a.m. the cooling power of the atmosphere is already approaching the minimum for the day. The diurnal range of cooling power is small (only 1.61 millicals per square cm. per sec. by the dry kata-thermometer). It is hoped that

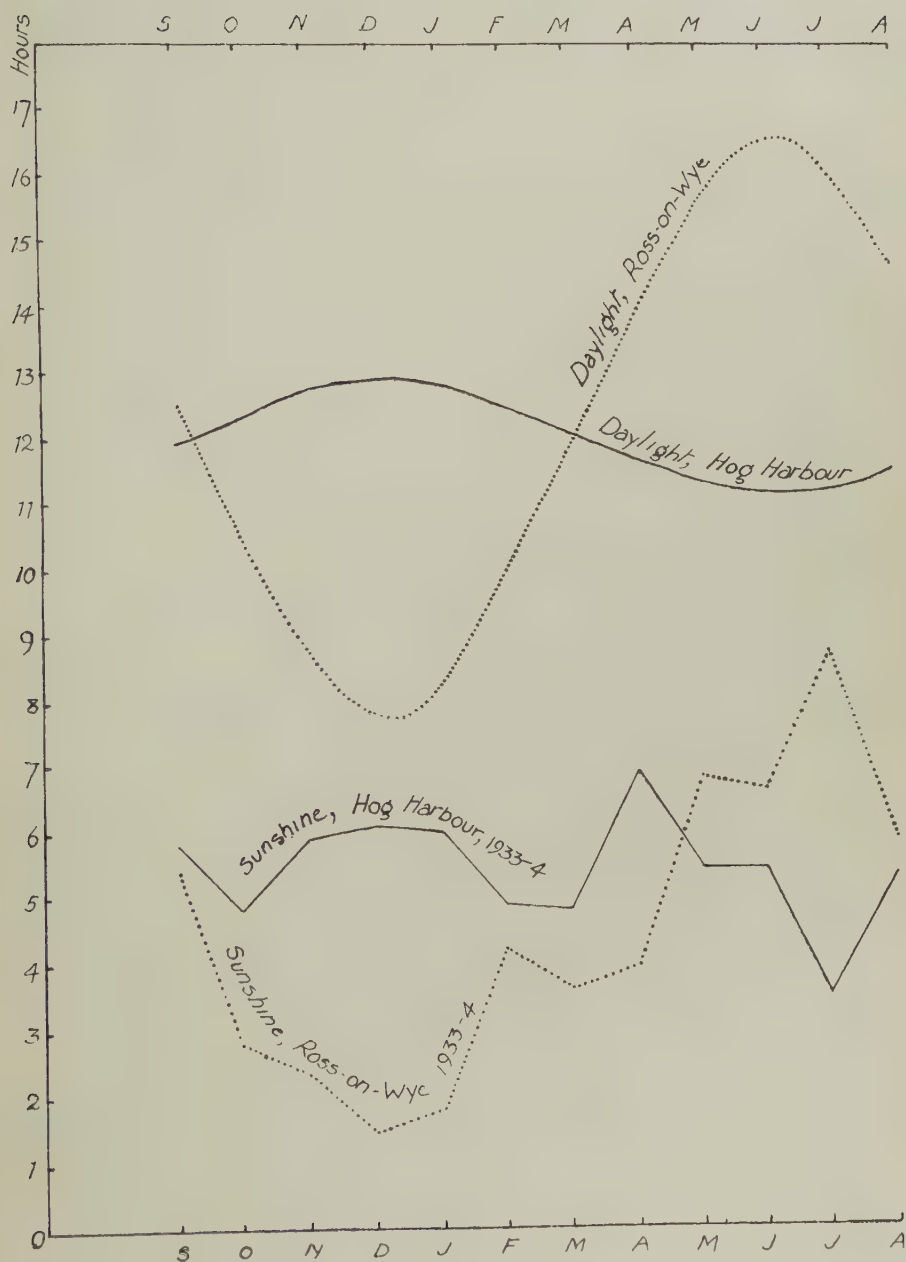


FIG. 6.—Mean daily hours of daylight and of sunshine at Hog Harbour and at Ross-on-Wye.

figures will be obtained in forests in other parts of the world for comparison of the annual and diurnal change. The kata-thermometer, by integrating the effects of temperature, humidity, and air currents, provides one of the best means of stating the action of climate upon organisms.

(4) *Light. (Length of daylight and of sunshine ; ultra-violet light ; twilight.)*

The longest day at Hog Harbour is about 13 hours 2 minutes and the shortest about 11 hours 14 minutes. A comparison of the seasonal change of length of day at Hog Harbour with that at an English station is shown in fig. 6. The sun passes overhead at Hog Harbour on 14 November and 8 February.

The mean daily number of hours of bright sunshine during 1933-4 at an English station (Ross-on-Wye) and at Hog Harbour is also shown in fig. 6. One sees at a glance that the distribution of sunshine is strongly seasonal in England, while at Hog Harbour no obvious rhythm is detectable. In the year under consideration (and there are no data for any other year) April was the sunniest month and July the cloudiest. It must be remembered, however, that April is usually a very wet month, and that April 1934 was exceptional in not being very wet. It is improbable that there is a tendency to any regular seasonal rhythm in hours of sunshine.

Ultra-violet light was measured during certain months only. The mean number of units of ultra-violet light daily were as follows :—September, 6·4 ; October 6·7 ; December 7·6 ; February 3·5 ; June 2·1. (Very low figures were obtained during July and August ; but as the quartz tube was cracked at the time, we have disallowed them.) The method of measuring ultra-violet light by the fading of the acetone methylene blue solution is open to criticism, but the low figures obtained in February and June are probably significant. The low figure in June may be caused by the light having to filter a greater distance through the air during this month than during any other, the sun's rays being then more oblique. During February the sun passes directly overhead, and the low amount of ultra-light is to be ascribed, partly at least, to the cloudiness during this month. In Samoa, which is in nearly the same latitude, February is the cloudiest month in the year (Buxton, 1927).

The mean times of disappearance of the white spot, indicating the end of twilight, are shown in the table :—

Month.	Number of observations.	Mean time of sunset on the nights of observation.	End of twilight.	Mean duration of twilight (minutes).
		p.m.	p.m.	
Dec. 1933	4	6·24	7·16	52
Jan. 1934	5	6·32	7·09	37
Feb. 1934	4	6·30	7·04	34
Mar. 1934	10	6·13	6·46	33
Apr. 1934	10	5·53	6·36	43
May 1934	7	5·38	6·41	63
Aug. 1934	10	5·47	6·31	44

It is clear that the period of twilight is always short and varies irregularly during the year. It is hoped that comparable observations will be made in other parts of the world.

- (5) *Humidity.* (*Rainfall; relative humidity; saturation deficiency; absolute humidity; evaporation.*)

The rainfall has already been mentioned in the general remarks on the climate

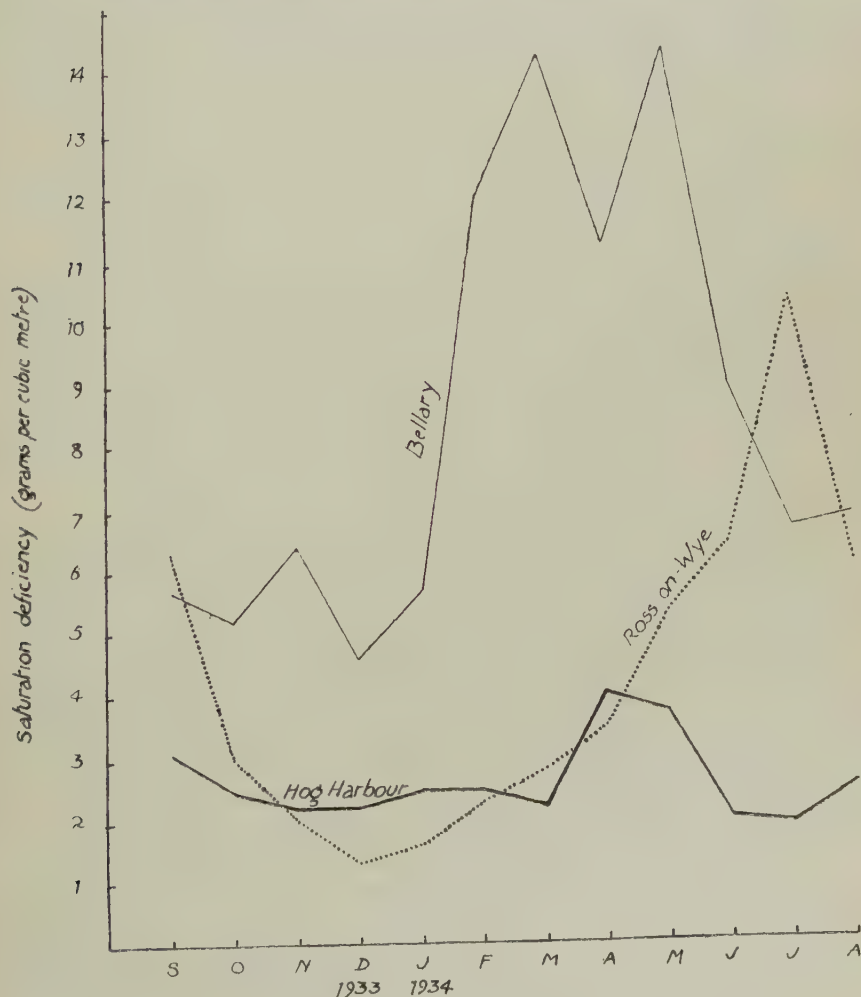


FIG 7.—Saturation deficiencies, 1933-4.

during 1933-4, and illustrated in the hythergraph, fig. 2 A. It will be recollected that April and May, which are usually very wet months, were relatively dry.

The relative humidity was measured daily in the forest at 2 p.m. It was at its lowest (85 per cent.) in April and May. During the other months it varied irregularly between 87 per cent. and 91 per cent., the latter being the figure during five of the months. During one week (19–25 December 1933, inclusive) it was also measured daily at 4 a.m. and the following figures were obtained :—98, 96, 95, 96, 98, 96, 100.

Prof. P. A. Buxton (1931) has stressed the significance of the saturation deficiency of the atmosphere in biological investigations. Saturation deficiency may be expressed as the number of grams of water that a cubic metre of a given sample of air is capable of absorbing, and this depends upon the existing temperature and relative humidity. It is an index of the drying power of

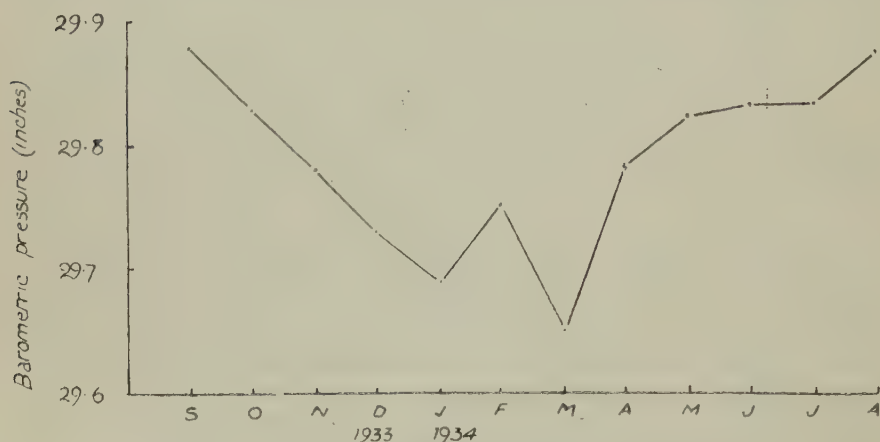


FIG. 8.—Barometric pressure at Hog Harbour, 1933–4.

the atmosphere. One of us (Baker, 1935 *b*) has designed nomograms for the rapid calculation of saturation deficiency, which were used in the preparation of fig. 7. In this graph the mean monthly saturation deficiency in the forest at Hog Harbour at 2 p.m. is compared with that at two selected stations during the same period (September 1933 to August 1934). These stations are Ross-on-Wye, England, and Bellary, South India. The former was chosen to show how greatly and how regularly the drying power of the atmosphere varies during the year, despite the small seasonal changes in rainfall. Bellary was chosen as typical of monsoon areas, with their enormous seasonal change in saturation deficiency. Unfortunately there is no standard time of day for reading wet and dry bulb thermometers. At Bellary the readings were made at 8 a.m., and at Ross-on-Wye at 1 p.m. Despite these differences in time, general tendencies during the year may be observed. The Hog Harbour graph shows no definite seasonal tendency, though the two exceptional months, April and May, show up as significantly drier than the others. The rest of the year is remarkably uniform in saturation deficiency.

The absolute humidity in the forest at Hog Harbour is always high and does not change much during the year. Curiously enough, it reached its highest (23.0 grams per cubic metre) in the month (April) in which the rainfall was least, and its lowest (19.8 grams per cubic metre) in July. The dampness of the atmosphere is reflected in the rapid decay of leather objects, the sticking up of unused envelopes, etc.

No definite seasonal cycle can be traced in the amount of evaporation in the forest, though it varied considerably from month to month. (See Appendix. In April high winds temporarily destroyed the foliage protecting the evaporimeter from the direct rays of the sun, and the readings of that month have therefore been discarded.)

(6) *Barometric pressure.*

It is a remarkable fact that of all the meteorological readings that we took, the most definitely seasonal are those of barometric pressure (fig. 8). The readings were made at 1.45 p.m. daily. With the exception of only one month (February), there was a regular decrease of pressure from September to March. Thereafter there was an increase until August, without any month having a lower pressure than the month before it. The difference between the months of highest and lowest pressure (September and March) was, however, only 0.23 inch. In the absence of any experimental evidence to the contrary, it seems likely that this seasonal change is too small to have any appreciable influence on organisms.

SUMMARY.

(1) In connexion with an investigation of the reproduction of organisms in a climate which varies little during the year, meteorological observations were made from September 1933 to August 1934 at Hog Harbour, Espiritu Santo, New Hebrides (15° 15' S. latitude). Special attention was paid to the measurement of the climate in which the animals actually live, namely in the rain-forest.

(2) In general, the climate at Hog Harbour is hot and wet from June to October, and slightly hotter and considerably wetter from November till May. There is no dry season, the least wet month having, on the average, about twice as much rain as the wettest month in England. The year under investigation conformed to the average except that April and May were less wet than usual.

(3) The mean temperature only varied by 2°.1 C. (3°.8 F.) between the hottest and coldest months. In England during the same period the seasonal change was about eight times as great.

(4) The distribution of rainfall is exceptionally unseasonal for a tropical region, since the wettest month receives on the average only 2.5 times as much rain as the least wet. An analysis of meteorological data from the whole of the tropics shows that such a low figure as this is very rare.

(5) The cooling power of the atmosphere, as measured by the kata-thermometer, was greater in July and August than in the other months, but the difference was small.

(6) There is no obvious seasonal distribution of daily hours of sunshine, but there appears to be much less ultra-violet light in certain months (e.g. June) than in others.

(7) The saturation deficiency of the atmosphere was almost uniform throughout the year, except that it was higher during April and May. The amount of evaporation varied considerably from month to month, without disclosing any distinct seasonal tendency.

(8) Barometric pressure varied only very slightly during the year, but its variations were very regular and indeed constitute the most regular seasonal change observable in the climate.

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APPENDIX.—*Monthly means of the meteorological records.*

Maxi- mum.	Mini- mum.	Forest maxi- mum.	Forest mini- mum.	Grass mini- mum.	Earth (forest).	Dry kata- thermo- meter (forest), 2 p.m.	Wet kata- thermo- meter (forest), 2 p.m.	Rain- fall.	Relative humidity (forest), 2 p.m.	Saturation deficiency (forest), 2 p.m.	Evapori- meter (forest).	Sun- shine.	Ultra- violet light.	Baro- metric pressure.
° C.	° C.	° C.	° C.	° C.	° C.	Milli- calories per square cm. per sec.	Milli- calories per square cm. per sec.	Mean daily, mm.	Per cent.	Grams per cubic metre.	Mean daily, Livingston units.	Mean daily, hours.	Mean daily, units minus glass units.	Inches.
September 1933 . . .	28.3 ²⁶	22.1 ²⁶	26.2 ²⁵	22.0 ²⁰	21.0 ²⁴	24.4 ²⁵	4.69 ²⁵	10.0 ²⁵	87 ²⁵	3.1 ²⁵	1.60 ²¹	5.8 ²⁵	6.4 ²⁵	29.88 ²³
October 1933 . . .	28.1	21.8	25.1	22.4	20.5	24.1	4.64	10.4	89	2.5	1.13	4.8	6.7	29.83
November 1933 . . .	29.1	22.7	26.2	22.9 ²⁴	21.2	24.9	4.38	9.38	91	2.2	0.88	5.9	..	29.78
December 1933 . . .	29.9	22.6	26.7 ²³	22.5	21.1	25.0	4.15	8.90	91	2.2	1.11	6.1	7.6 ²³	29.73
January 1934 . . .	29.9	23.3	27.0	22.8	21.6	25.4	3.82	9.48	90	2.5	1.27	6.0	..	29.69
February 1934 . . .	29.9	23.2	26.7	22.6	21.1	25.4	4.18	9.48	90	2.5	1.13	4.9	3.5	29.75
March 1934	29.9	22.9	27.2 ²⁷	22.4 ²⁷	21.0	25.4	4.28 ²⁷	9.30 ²⁷	91 ²⁷	2.2 ²⁷	0.41	4.8	..	29.65 ²⁷
April 1934	30.2	22.9	27.6 ²⁵	22.6 ²⁴	21.2 ²³	26.2 ²⁴	3.50	9.48	85 ²⁴	4.0 ²⁴	..	6.9	..	29.78
May 1934	30.3 ³¹	22.1	26.2 ¹⁹	21.7 ²⁰	20.5 ²⁰	25.5 ²⁰	4.36 ²⁰	9.86 ²⁰	85 ²⁰	3.7 ²⁰	1.17	5.4	..	29.82 ²⁰
June 1934 . . . . .	..	22.1	25.3	21.9	20.6	24.8	4.48	10.3	91	2.0	1.48	5.4	2.1	29.83
July 1934	27.4 ¹⁴	21.6	24.3	21.1	20.4	24.2	5.27	10.4 ²⁷	91	1.9	0.31	3.5	..	29.83
August 1934	27.8	21.2	25.5	20.9	20.2	23.8	4.94	11.4	89	2.5	0.91	5.3	..	29.87

NOTE.—When any of the means in this table is based upon less than twenty-eight daily observations, the number of observations is given in small letters after the figure concerned.

A contribution to our knowledge of the biology of certain sawflies of the genus *Empria* Lep. (Hymenoptera Symphyta). By HERBERT W. MILES, M.Sc., Ph.D. (Victoria University of Manchester). (Communicated by Prof. H. G. CANNON, M.A., Sc.D., D.Sc., F.R.S., F.L.S.)

(PLATE 8 and 2 Text-figures *)

[Read 5 March 1936]

SAWFLIES of the genus *Empria* Lep. (*Poecilostoma* Dahlb.) are fairly common in spring and early summer. Perkins (13) has taken nine species in Devonshire, and recognises about eleven or twelve species in Britain. Seven species have been recorded for Lancashire and Cheshire (1, 10), and a few species are named in lists of sawflies for other counties.

Very little is recorded of the biology of the members of this genus. Cameron (3) describes and figures the larva of *E. pulverata* Retz., which feeds on alder, and gives a short account, based on that of Kaltenbach, of the larva of *E. abdominalis* F. He also associates *E. longicornis* C. G. Thoms. with *Spiraea Ulmaria*, and mentions breeding *E. liturata* Gmel. from bramble stems. Loisel (6) records larvae of *E. tridens* Kon. feeding on leaves of raspberry. Coward (4) records adults of *E. abdominalis* F. at Rostherne, Cheshire, in early July, but does not associate any plant with his captures. Enslin (5) gives a short summary of the biology of *E. abdominalis*, and a list of the host plants previously recorded. He also describes other species of *Empria*, and summarises the biology as observed on the continent of Europe, associating *E. excisa* C. G. Thoms. with *Salix*, *Epilobium*, and *Pteris aquilina*, *E. immersa* Klug with *Salix*, and *E. liturata* Gmel. with *Fragaria*. In his notes on the sawflies of Devonshire, Perkins states 'The commonplace larvae of several species are frequently seen on meadowsweet (*spiraea*)', and adds 'The species appear in spring and early summer and have no second brood'. The only species he associates definitely with *Spiraea*, however, is *E. pumila* Kon.

It is apparent that little is known of the immature stages, feeding-habits, and reproduction of the genus *Empria*. In this paper I have given a detailed account of *Empria tridens* Kon. and *Empria abdominalis* F. Material for the studies was obtained in Lancashire and Cheshire. I am indebted to Mr. Morris Cohen, M.Sc., for assistance with the preparation of the figures, and to Mr. R. B. Benson, M.A., of the British Museum, for calling my attention to Loisel's record of *E. tridens* and for examining specimens from time to time. I am also grateful to Professor H. Graham Cannon, F.R.S., for the very friendly interest he has taken in the progress of the work.

* The cost of the reproduction of these illustrations has been borne by the Westwood Fund.

TAXONOMY OF THE ADULTS.

Empria tridens Kon. seems fairly typical of the genus *Empria* Lep., and has the characteristic pale transverse areas (fig. 1) on certain of the abdominal terga. *E. abdominalis* F. differs from other British species of *Empria* in having the abdomen entirely reddish yellow, except for occasional median black flecks on the last two or three terga. Morice (12) has noted that the wing venation is variable in the genus *Empria* and is not always consistent within the species. In *E. tridens* (Pl. 8, fig. 1) there are three cubital cells in the fore-wing as in *Emphytus* Kl., while in *Empria abdominalis* (Pl. 8, fig. 4) there are four cubital cells as in *Eriocampa* Htg. Both species resemble *Emphytus* in having a single medial enclosed cell in the hind wing. In *Empria tridens* the clypeus has a definite median keel, which is produced anteriorly so that the clypeus appears tridentate, while in *E. abdominalis* the clypeus is evenly emarginate. Antennæ of *E. tridens* taper towards the tip, while those of *E. abdominalis* are slightly thickened, and the general shape of the head in the two species shows considerable differences.

Descriptions of *E. tridens* and *E. abdominalis* and other species of *Empria*, and keys for their determination are given by Morice (12) and by Enslin (5).

BIONOMICS OF *EMPRIA TRIDENS* KON.*Oviposition and incubation.*

The flight period for *Empria tridens* extends over May and June, and during these months the imagines may be swept from low herbage. They are often taken in association with Dolerids, with the smaller species of which they may, at first sight, be confused. Females are active, and run about the stems of raspberry seeking sites for oviposition. Males are strong fliers, and fly restlessly from bush to bush in search of females.

The females lay eggs in pocket-shaped incisions in the leaf stalks, in the edges of young leaves, and sometimes in the fleshy scales of the buds. The eggs are elliptical, and at first rather flat and difficult to detect in the tissue. During the first four or five days of incubation they increase in size, and their positions become visible as oval swellings, from which the eggs may be partly protruded. About three days before eclosion the dark ocelli and brown tips of the mandibles are apparent through the chorion, and the outlines of the head and body segments are visible as the larva moves within the egg.

The incubation period for eggs under observation was 12-17 days. At eclosion the larva ruptures the chorion with the mandibles.

Habits and description of larval stages.

Newly hatched larvae appear to find movement over the host plant difficult because of the fine pubescence that thickly covers the under side of the leaves and the leaf stalks. They begin to feed on the under sides of the leaves and eat

out shallow depressions in the surface tissue. As they become stronger they bite further into the leaves and gnaw out small irregular holes, which, by the time the larvæ are three days old, are large enough to attract attention. From this time onwards the larvæ feed on the under sides of the leaves with the head at the edge of the feeding hole and the tip of the abdomen curled.

After the first few days the larvæ feed at night, and during the day they remain motionless for long periods with the head near the edge of the broken tissue. They are very sensitive to disturbance, and, though they appear to ignore the stirring of the plants in the wind, the lightest touch of the observer

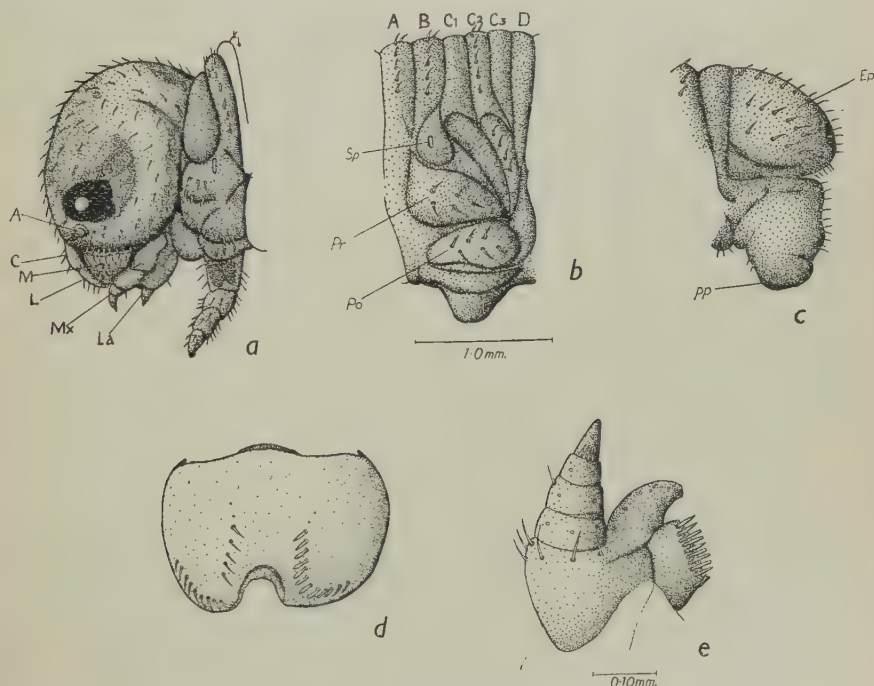


FIG. 1.—Larva of *Empria tridens* Kon.

- a.* Head, lateral view. *A*=antenna; *C*=clypeus; *M*=mandible; *L*=labrum; *Mx*=maxilla; *La*=labium. *b.* Fifth body segment, showing annulation (lettered according to Middleton). *Sp*=spiracle; *Pr*=pre-epileurite; *Po*=post-epileurite. *c.* Caudal segment (lateral view); *Ep*=epiproct, *pp*=post-pedes. *d.* Labrum, ventral surface. *e.* Maxilla.

causes them to fall from the plants as a tight ball, which may roll for some distance. They remain tightly rolled for some time before re-ascending the stems of the host plant.

Young larvæ are smoky grey, with the body finely and closely annulated, and the head dark. Later the head becomes greenish, and finally yellowish brown, and the body becomes greyish green above and pale grey beneath.

The mature larva of *E. tridens* (Pl. 8, figs. 2 & 3) is 13-15 mm. long. The head is shining yellowish brown, with a small dark triangular mark on the vertex. The body is greyish green above and light grey beneath, and the colours meet along the line of spiracles. The thoracic legs are pale, with the tarsal claws brown and brown areas on the coxae. Prolegs occur on segments 5-11 and on segment 13, and pseudocerci are absent.

The head (fig. 1 a) is clothed with short pale setae. The ocelli are black, and surrounded by a dark area that extends towards the small triangular dark area on the vertex. The frons is light brown. The antennae are light brown

TABLE I.—*Duration of larval stadia (in days).*

Larva.	1st stadium.	2nd.	3rd.	4th.	5th.	Total.	Sex.
No. 1.....	10	5	4	10	..	..	..
2.....	10	4	3	8	7	32	♂
3.....	10	5	5	10	3	35	..
4.....	11	4	3	10	16	44	..
5.....	10	3	4	9	3	29	..
6.....	10	3	4	9	2	28	..
7.....	11	3	4	8	3	29	..
8.....	11	3	5	9	..	..	..
9.....	11	3	5	9	8	36	♂
10.....	11	4	5	8	..	..	..

TABLE II.—*Width of frons in millimetres.*

Larva.	1st instar.	2nd.	3rd.	4th.
No. 1.....	0.25	0.34	0.43	0.53
2.....	0.27	0.34	0.43	0.54
3.....	0.27	0.35	0.43	0.55
4.....	0.27	0.35	0.44	0.56
5.....	0.27	0.35	0.44	0.56
6.....	0.25	0.34	0.43	0.55
7.....	0.25	0.34	0.43	0.55
8.....	0.25	0.35	0.44	0.55
9.....	0.25	0.35	0.44	0.55
10.....	0.27	0.34	0.44	0.55
Average width ..	0.260	0.345	0.435	0.549
Growth ratio ....	..	1.32	1.26	1.24

and prominent, and have five segments, the apical segment being longer and paler than the rest. The labrum (fig. 1 *d*) is emarginate and asymmetrical, and each lobe has a row of stout, variously shaped spines along the edge on the inner surface. The mandibles are dark brown and have two or three large teeth, some of which may be slightly dentate on the inner margin. The maxillae (fig. 1 *e*) are large and fleshy; the galea is prominent, sub-conical, and slightly curved inwards; the lacinia has a row of short stoutish bristles, and the palpus has four segments. The labium is rather broad and fleshy, and bears stout three-segmented palpi.

The body is greyish green dorsally, and is darkest immediately above the conspicuous light spiracular line. The ventral surface of the body and the prolegs are pale grey. Segments 4–11 each have six annulets (fig. 1 *b*). Setae occur dorsally on annulets A, B, and C₂, and there are a few setae on the posterior alar area and on the pre- and post-epipleurites. The caudal segment (fig. 1 *c*) bears short fine pale setae on the sub-anal lobe and on the epiproct, which has also a small brownish area near the posterior edge.

After feeding for a time larvae in the final instar become deeply wrinkled, and contract until they are only 10–11 mm. long. The colour changes from greyish green to a dull yellowish green, with a greyish lateral stripe just above the spiracular line. The ventral surface of the body and legs and prolegs become pale yellowish.

Details concerning the duration of larval stages and the rate of growth of ten larvae of *E. tridens* are given in Tables I and II. These larvae were produced parthenogenetically; all were males and became fully fed in the fifth instar. The first and fourth feeding stages are fairly long and extend over 10–11 and 8–10 days respectively, while the intermediate stages are much shorter and occupy only 3–5 days each. During the fifth stage the larvae finished feeding and then became quiescent, while ingested food was completely assimilated. The feeding period varied from 1 to 3 days, and the period of inactivity from 1 to 13 days. The total larval life lasted 29 to 44 days. The width of the frons in successive instars was taken as an index of larval growth, and data given in Table II indicate that growth was fairly regular throughout larval life. The average growth ratio (8) was 1.27.

Pupal stage.

After a quiescent period larvae of *E. tridens* leave the host-plant and tunnel into dead stems of raspberry and bramble, pithy stems of other plants, or into dead wood or soft bark. The entrance to the tunnel is closed by a compact mass of fragments, which appear to be cemented with saliva near the entrance to the pupal chamber. The pupal chamber is oval, with the sides smoothly finished, but not lined with silk or parchment, and the insect makes no cocoon. Within the pupal chamber further contraction takes place, and the larvae remain in a wrinkled prepupal condition throughout the autumn and winter. Pupation takes place in the following spring.

Annual cycle.

Empria tridens is univoltine. Adults are on the wing in May and June, and larvae occur on *Rubus* during June and early July. About the middle of July the larvae pass into the pre-pupal condition and tunnel into stems of dead wood for hibernation and pupation. Pupation takes place in the spring.

Parthenogenesis.

Parthenogenesis is common in *Empria tridens*. The species is arrhenotokous or male-producing, and males and females occur in about equal numbers.

BIONOMICS OF *EMPRIA ABDOMINALIS* F.*Oviposition and incubation.*

Adults of *E. abdominalis* may be found on plants of *Lysimachia nummularia* L. from the middle of May until the middle of August. They are rather sluggish and rest upon the leaves for considerable periods, during which they occasionally preen the antennae and stroke the wings with the legs. At intervals they run actively from leaf to leaf testing the surfaces with slightly protruded terebrae. Sometimes they take short circling flights and alight again on the host plant, often within a few inches of the point from which the flight was begun. After such flights the insects usually run about amongst the trailing stems of the host plant until they have selected leaves suitable for oviposition. Selection of a site for egg-laying may take some time. The epidermis of the leaf appears to be tough and the mesophyll shallow, and a female may pierce a leaf several times or even pass to another leaf before inserting an egg.

At oviposition the terebrae are inserted into the tissue of the leaf, and a large, almost circular incision is made in the mesophyll near the lower epidermis, usually well within the periphery. The egg is then passed into the incision and the ovipositor withdrawn.

The eggs are usually laid singly in the leaves and widely distributed over the host plant, though occasionally two or three eggs occur in one leaf. They are roughly circular, and 1.5–2 mm. in diameter, larger than eggs of most Nematine sawflies, but resembling those of *Emphytus cinctus* L. The large size of the eggs in relation to the thinness of the leaf tissue makes them very conspicuous on the lower leaf surface (Pl. 8, fig. 5). During incubation the eggs of *E. abdominalis* swell slightly, but do not rupture the leaf tissue, and protrude from the egg pockets like those of some Nematine sawflies (9, 11).

The incubation period for eggs of *E. abdominalis* kept under observation in the laboratory varied from 7 to 11 days. At eclosion the larvae bite their way through the chorion and the lower epidermis of the leaf, and emerge through a ragged, slightly curved opening.

Growth and feeding habits of the larvae.

At eclosion larvae of *E. abdominalis* are 2.5–3 mm. long, which is larger than most sawfly larvae at eclosion, but is compatible with the size of the eggs. They are dull smoky white in colour with the head dark, but after feeding has begun the ingested food gives them a suffused greenish colour along the mid-dorsal line. When they are four or five days old the head is pale brown, the ocelli black, the antennae pale, and the trophi dark brown. The thoracic legs are transparent, with light brown tarsal claws, and the prolegs are also transparent. The thorax is rather broader than the abdomen, and the body tapers posteriorly. The annulation is fine and even, as in larvae of *Macrophya* and *Emphytus*.

Larvae in the first instar feed on the under sides of the leaves. At first they devour the epidermis and the mesophyll, and leave intact the upper epidermis, which becomes dry and brown. Later they bite through the leaves and make small ragged holes in the tissue. As feeding continues the holes become larger, and merge until the leaf is skeletonized. Owing to the larvae falling from the leaves when disturbed and regaining the plant at some other point, the feeding sites become widely distributed and inconspicuous, and not readily observed.

In the later stages the larvae (Pl. 8, figs. 6 & 7) feed in the densest parts of the plants or lie curled on the under sides of the leaves during the day. Towards evening they become active and wander on to the upper leaves to feed, but they retreat again in the early morning before the light becomes intense. These older larvae eat semicircular or shallow curved areas out of the leaf margins, and, since the frass falls clear of the upper foliage, their presence on the plant is not easily detected. After careful examination, however, the irregularities in the outlines of the upper leaves are seen, and exuviae may be found attached to lower leaves, leaf stalks, and prostrate stems. Larvae lying curled on the under sides of the leaves drop, tightly curled, into dense vegetation or cracks and crevices in the soil when they are disturbed.

Larvae of *E. abdominalis* reach maturity in three to four weeks. The mature larva is 22–25 mm. long. It is dark olive-green dorsally, but appears greyish because the back and sides are coated with a fine powdery or flaky substance. This powdery coating has also been observed in *Empria pulverata* Retz. and *Eriocampa ovata* L., but in these species it is thicker and more pronounced than in *E. abdominalis*. The ventral surface of the body is pale grey or whitish and lightly suffused with pale green.

The head (fig. 2 a) is yellowish with large black ocelli. On the vertex there is a large dark brown mark which extends forwards as a narrow dark streak along the epicranial suture to the apex of the frons, where it becomes broadly diffused and disappears. The lower part of the frons and the clypeus are yellow or pale yellow. The mouth-parts resemble those of *E. tridens*. The labrum (fig. 2 d) is shallowly emarginate and bears two long setae on its upper surface and a row of short bristles along the margin of the under surface. The mandibles

are large and strongly sclerotised towards the tips and have two or three large teeth, the second of which may be slightly dentate. The maxillae (fig. 2 *e*) are stout and fleshy. The lacinia is broad and carries a row of short stout lacinial bristles. The galea is stout and curves inwards, and has a number of pits on its outer surface. The palpus has four segments, the apical segment being long and conical. The palpiger is broad and fleshy, and bears a few scattered setae. The labium is broad and fleshy, and the short stout labial palpi have three segments. The mouth of the salivary duct lies between the palpi and protrudes slightly.

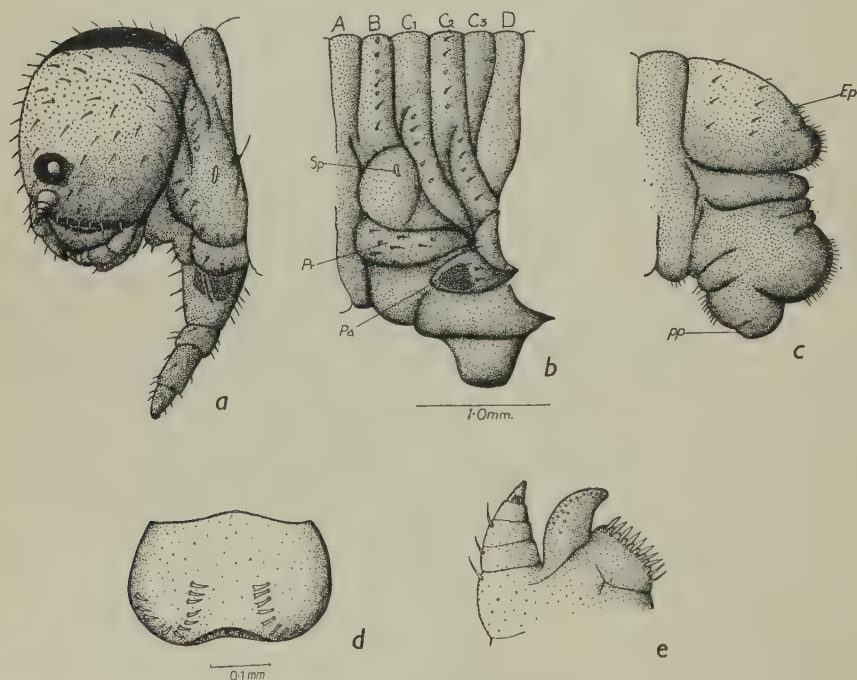


FIG. 2.—Larva of *Empria abdominalis* F.

a. Head, lateral view. *b.* Fifth body segment showing annulation.
c. Caudal segment. *d.* Labrum. *e.* Maxilla.

On the body the dark dorsal colour and the pale ventral colour meet (Pl. 8, fig. 7) along the line of the lateral tracheae, which are visible through the skin as a white line between the spiracles. The legs are pale green with the coxae and tarsal claws brown, and sparsely covered with short colourless setae. The prolegs (uropods and postpedes of Middleton (7)) are pale. There is a row of dark spots anteriorly on the post-epipleurites, but on segment 11 the spot is pale and it is absent from segments 12 and 13. The segments are closely

and evenly annulated (Pl. 8, fig. 7), and the arrangement of the annulets (fig. 2 *b*) is similar to that of *E. tridens*. As in *E. tridens* annulets B and C 2 bear short pale setae on the sides and back, but annulet A has no setae. C 1 has a few setae laterally, and a few setae also occur on the pre- and postepipleurites. The caudal segment (fig. 2 *c*) bears no pseudocerci, but is clothed with fine pale setae on the epiproct and the sub-anal lobe.

At the fifth moult larvae of *E. abdominalis* enter the prepupal stage. The dark area on the vertex, characteristic of the earlier instars, is absent in the

TABLE III.—*Duration of larval stadia in two generations of E. abdominalis.*

1st generation.

Larva.	1st. stadium.	2nd.	3rd.	4th.	5th.	Total.	Sex.
	days.	days.	days.	days.	days.	days.	
No. 1.....	8	4	3	4	6	25	♀
2.....	8	4	2	3	5	22	"
3.....	8	4	2	4	4	22	"
4.....	8	4	2	3	5	22	"
5.....	8	6	3	4	4	25	"
6.....	8	4	2	4	5	23	"
7.....	8	4	2	4	7	25	"
8.....	8	4	2	4	5	23	"
9.....	8	4	2	4	4	22	"
10.....	8	4	2	5	6	25	"

2nd generation.

Larva.	1st. stadium.	2nd.	3rd.	4th.	5th.	Total.	Sex.
	days.	days.	days.	days.	days.	days.	
No. 1 A.....	8	4	4	3	6	25	♀
2 A.....	8	2	3	3	6	22	"
3 A.....	8	2	3	5	7	25	"
4 A.....	7	3	3	5	8	26	"
5 A.....	8	2	3	5	6	24	"
6 A.....	8	2	2	3	7	22	"
7 A.....	7	2	3	5	8	25	"
8 A.....	8	2	2	5	7	24	"
9 A.....	8	2	3	6	6	25	"
10 A.....	7	3	2	3	7	22	"
Range....	7-8	2-6	2-4	3-6	4-8	22-26	

TABLE IV.—*Growth in larvae of E. abdominalis as indicated by width of frons (in mm.).*

1st generation.

Larva.	1st instar.	2nd.	3rd.	4th.	5th.
No. 1.....	·30	·36	·47	·65	·75
2.....	·28	·37	·50	·65	·78
3.....	·29	·36	·47	·60	·77
4.....	·30	·37	·47	·65	·82
5.....	·29	·38	·49	·66	·80
6.....	·30	·37	·49	·65	·80
7.....	·30	·36	·50	·65	·80
8.....	·29	·36	·47	·65	·80
9.....	·30	·36	·47	·65	·80
10.....	·30	·36	·49	·66	·78
Average	·295	·365	·482	·647	·79
Growth ratio.	..	1·24	1·32	1·34	1·22

2nd generation.

Larva.	1st instar.	2nd.	3rd.	4th.	5th.
No. 1 A.....	·30	·37	·45	·62	·75
2 A.....	·30	·39	·50	·65	·78
3 A.....	·30	·40	·47	·58	·78
4 A.....	·32	·39	·47	·60	·73
5 A.....	·32	·41	·50	·58	·75
6 A.....	·30	·39	·50	·62	·75
7 A.....	·30	·39	·47	·63	·77
8 A.....	·30	·40	·50	·62	·77
9 A.....	·30	·40	·50	·63	·75
10 A.....	·31	·41	·50	·65	·75
Average	·305	·395	·486	·68	·758
Growth ratio.	..	1·29	1·23	1·27	·122

prepupal stage, and the head is entirely yellow. The body is clear deep green dorsally and very pale green ventrally. Shortly after this moult the larvae desert the host plant and enter the soil. It is probable that larvae of *E. abdominalis* have the same number of larval stages as *E. tridens*, since females of *E. abdominalis* have six larval stages and males of *E. tridens* have five larval stages, and it is usual to find among sawflies that females have one ecdysis more than males of the same species. Larvae of *E. abdominalis* differ from those of *E. tridens* in that larvae of *E. abdominalis* do not feed in the final larval stage, while those of *E. tridens* feed for some time in the final larval stage before tunnelling into dead wood or pithy stems for hibernation.

Larval growth and development is steady, and shows comparatively little variation in individuals of the same provenance when they are reared under similar conditions. The range of variation in two successive generations of larvae is indicated in Tables III and IV. The first and fifth larval stages are long, and occupy 7-8 and 4-8 days respectively, while the second, third, and fourth larval stages are shorter, each varying from 2-6 days. The growth of the larvae, as indicated by the width of the frons in successive instars, is fairly uniform. In the first instar the width of the frons is 0.3 mm., and in the fifth instar the width varies from 0.76-0.79 mm. The average growth ratio obtained from data given in Table IV is 1.26.

Pupation.

For a few hours after the fifth ecdysis larvae of *E. abdominalis* rest motionless on the soil beneath the host plant or lie extended on the prostrate stems. They then burrow into the earth until they reach soil sufficiently consolidated to permit the formation of earthen cells. The cells are shaped in closely packed soil and the walls pressed firmly by movements of the larvae. No saliva appears to be used in the construction of the cell, and it cannot be separated from the surrounding soil.

Within the pupal cell the larva contracts, and later the final larval skin is shed. The period spent in the soil in the prepupal and pupal stages varies from 9 to 27 days during the summer. The generation of larvae that reach maturity in the late summer and early autumn hibernate as prepupae in earthen cells.

Annual cycle.

Empria abdominalis is multivoltine. In the Manchester district there were three generations during the summer of 1935. Each generation required 38-52 days to complete the cycle from oviposition to the emergence of the adults. Adults from larvae that hibernated during the winter of 1934-35 were on the wing in late May and early June, and the first generation of larvae were present on the plants during June. These larvae entered the soil during late June and early July, and produced the second generation of adults during July. These adults produced larvae that matured towards the end of July and in early August, and the third generation of adults were on the wing about the

middle of August. The third generation of larvae reached maturity in September and entered the soil for hibernation. Observations made during other years indicate that in some seasons there are only two generations, and the second generation of larvae reach maturity towards the end of August and enter the soil for hibernation.

Parthenogenesis.

Empria abdominalis differs from *E. tridens* in being thelytokous or female-producing, and reproduction by parthenogenesis appears usual. While the species has been under observation, considerable numbers of adults have been reared, but no males have occurred, and no males have been taken out of doors during extensive field-collecting. Enslein (5) describes the male of the species, but states that it is rare on the continent.

DISCUSSION AND CONCLUSION.

The study of *Empria tridens* and *E. abdominalis* indicates that, although the insects are grouped in the same genus, there are important differences between them. The general form and colour of the adults is strikingly different (Pl. 8, figs. 1 & 4), and there are marked differences in the wing-venation and shape of the antennae. The life-cycle differs greatly in the two species: *E. tridens* is univoltine and males and females are readily found, and *E. abdominalis* is multivoltine and males are practically unknown. Parthenogenesis occurs in both species: *E. tridens* is arrhenotokous or male-producing, but *E. abdominalis* is thelytokous or female-producing, and appears to depend entirely on parthenogenetic reproduction for the continuance of the species.

Larvae of the two species of *Empria* present certain differences. The number and arrangement of the annulets are similar in both species, but *E. tridens* has more setae-bearing annulets than *E. abdominalis*. Larvae of *E. tridens* feed during part of the final larval stage, but larvae of *E. abdominalis* seek out pupation sites immediately after entering the final larval stage. Larvae of *E. tridens* tunnel into bark, dead wood, or pithy stems for hibernation and pupation, while larvae of *E. abdominalis* pupate in the soil. Both species pupate without constructing a cocoon.

In the absence of information regarding the biology of other members of the genus *Empria*, it cannot be stated with certainty which of the species is typical. A study of the adults suggests that *E. abdominalis* is not a representative species, and Costa, as stated by Cameron (3), has placed it in a separate genus, *Monostegia*. Enslein (5) also appreciates the divergences within the genus *Empria* Lep. He places *E. abdominalis* with *E. pulverata* Retz., which is also multivoltine and thelytokous (2), in a subgenus, *Monostegia* Costa, and creates a new subgenus, *Triempria* Enslein, in which he places *Empria tridens*. The biological differences herein described seem sufficient to justify some such subdivision of the genus *Empria* Lep.



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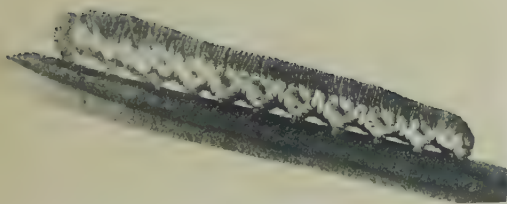
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3



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7



2

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EMPRIA TRIDENS Kon. and E. ABDOMINALIS F.

SUMMARY.

Studies of the biology of two species of *Empria* Lep., *E. abdominalis* F. and *E. tridens* Kon., reveal that *E. abdominalis* is a multivoltine species with thelytokous parthenogenesis and *E. tridens* is a univoltine species with arrhenotokous parthenogenesis.

E. abdominalis is associated with *Anagallis* and *Lysimachia*, and lays large conspicuous eggs in the under sides of the leaves. *E. tridens* feeds on *Rubus* spp., and inserts small inconspicuous eggs into stems, leaves, and bud scales of the host plant.

Larvae of both species are closely and evenly annulated. A typical abdominal segment has six annulets; in *E. abdominalis* the second and fourth annulets are setiferous, while in *E. tridens* the first, second, and fourth annulets are setiferous. Prolegs occur on segments 5–11 and 13 in both species and pseudocerci are absent. Larvae of *E. abdominalis* have the back and sides covered with a fine flaky or powdery substance which is absent in larvae of *E. tridens*. Females of *E. abdominalis* have six larval stages, in the last of which no feeding takes place. Males of *E. tridens* have five larval stages, in all of which feeding occurs.

In *E. tridens* hibernation and pupation take place within bark, dead wood, and pithy stems, while in *E. abdominalis* pupation takes place in the soil. Neither species constructs a cocoon.

The differences in biology and habits seem to justify the subdivision of the genus by Enslin into subgenera—*Monostegia* Costa, which includes *E. abdominalis*, and *Triempria* Enslin, which includes *E. tridens*.

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EXPLANATION OF PLATE 8.

Fig. 1. Adult ♂ *Empria tridens* Kon., showing wing venation and characteristic pale marks on the abdomen. ($\times 4\frac{1}{2}$.)

Fig. 2. Larva of *E. tridens*, dorsal view. ($\times 2$.)

Fig. 3. Larva of *E. tridens*, lateral view, showing the conspicuous spiracular line. ($\times 2$.)

- Fig. 4. Adult ♀ *Empria abdominalis* F., showing wing venation and the form of the antennae ($\times 3\frac{1}{2}$.)
- Fig. 5. Egg of *E. abdominalis* in leaf of *Lysimachia nummularia* L. ($\times 2$.)
- Fig. 6. Larva of *E. abdominalis*, showing the effect of the presence of the powdery coating on the back and sides. ($\times 3$.)
- Fig. 7. Larva of *E. abdominalis*, lateral view, to show the position of the prolegs, the annulation, the pale spiracular line, and the dark markings (somewhat obscured by the powdery secretion) on the post-epipleurites. ($\times 2$.)
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Descriptions and records of Nycteribiidae (Diptera Pupipara), with a discussion of the genus *Basilina*. By HUGH SCOTT, Sc.D., F.L.S. (Department of Entomology, British Museum [Natural History]).

(With 11 Text-figures *)

[Read 5 March 1936]

THE contents of this paper, my eleventh contribution to our knowledge of the remarkable bat-parasites of the family Nycteribiidae, are most conveniently treated in three sections, concerning forms which occur, respectively, (I) in Ceylon, (II) in China, and (III) in the New World. Some explanatory remarks are given at the beginning of each section. At the head of Section III will be found a general discussion of the genus *Basilina*, which includes practically all the species of Nycteribiidae recorded from North and South America; the American species are tabulated, with their range and hosts, and reference is made to the curious geographical distribution of the genus as a whole, so far as it is at present known, also to the great disparity between the number of species of Nycteribiidae hitherto discovered in the New World, compared with the much larger number occurring in the Old World. The genus *Basilina* is also touched on in Section I, where a new species occurring in Ceylon is described.

Another point of general interest lies in the description (p. 484) of the puparium of *Basilina eileenae*. This phase in the life-cycle has been described in very few species, but the form of the puparium in *Basilina eileenae* indicates that the procedure is the same in this as in other species. The full-grown larva, as soon as it emerges from the body of the parent, assumes a characteristic shape identical with that of the puparium, the dorsal surface being convex and the ventral flattened. It immediately adheres by its flattened ventral surface to the substratum, which may be the rocky walls of a cave, the wooden structure of the roof of a building, the branches and leaves of trees in which the bats hang, or (in one case at least) the body of the bat itself; in one species the female has been seen to press the larva down repeatedly on to the substratum with the ventral surface of its body; the larva then hardens and darkens in colour rapidly, and a chitinous exudation forms round its contour the characteristic flange which fastens it even more firmly.

The *types* of the new species described in this paper are in the British Museum; those of *Basilina ferrisi*, which I propose as a new species, but which was previously described by Ferris and erroneously referred to another species, are in his collection.

* The cost of reproducing these illustrations has been borne by the Westwood Fund,

Drawings. Those for fig. 5 were made some years ago in Cambridge by Mr. H. C. Gillings. The rest were done by myself in pencil with the aid of a drawing-apparatus, the 'inking over' and completion of certain parts being due to Miss D. Fitchew, who has devoted great care to the work.

Preservation of material. I still hold, though not all students of these insects agree with me, that Nycteribiidae should be examined, primarily, *in alcohol*, and that not all the specimens in a series should be cleared and mounted in balsam. When examples enough of a species are forthcoming, balsam-mounts form a valuable adjunct to specimens in spirit, while they are indispensable for precise determination of minute features of systematic importance, such as the number of facets in the eyes. But I have not found it desirable to base descriptions of new species or critical comparisons entirely on cleared specimens in balsam, in which there is often a certain amount of distortion and difficulty in discriminating between parts of the body. The natural form is frequently more clearly discernible in specimens in alcohol, viewed as opaque objects. My remarks on certain species (not new) discussed in this paper are less complete than they would have been, had I had specimens in spirit, and not only slides, for examination.

I am indebted to Mr. M. A. C. Hinton, F.R.S., for kindly checking the names of the bats in the table on p. 497.

I. DESCRIPTIONS AND RECORDS OF SPECIES OCCURRING IN CEYLON.

This section may be regarded as supplementary to my revision entitled 'Zoogeographical and systematic notes on the Nycteribiidae of India, Ceylon, and Burma' (Rec. Ind. Mus. xxvii, pp. 351-84, 1925), in which eleven species of Nycteribiidae were recorded from Ceylon. With the exception of *Nycteribia phillipsi* Scott, all these are known from India as well, several are even more widely distributed in the East, and several occur not only in the Orient but also in Africa. Their geographical distribution and their association with particular species and groups of bats were fully discussed in my paper cited above.

Many of the records from Ceylon were based on material collected by Captain W. W. A. Phillips, F.L.S., F.Z.S. Several other lots of specimens have been received from him since, one lot in 1925, too late for inclusion in my revision, and others at more recent dates. I am now able to describe both sexes and the puparium of a new species of *Basilia*, and also the male sex of *Nycteribia phillipsi*, previously known only from female examples. Additional records of species previously enumerated are also given, but only in cases where the records contain new data as to distribution or hosts.

The discovery of the species of *Basilia*, apparently the only known Nycteribiid parasite of a very rare bat, is specially interesting, since it is the first authentic representative of the genus *Basilia* from the Oriental Region*. As, however,

* *Basilia bathybothyra* Speiser having proved to belong to the genus *Penicillidia*, as explained below, p. 496, line 7 and second footnote,

this genus is almost confined to the Americas, and comprises almost (if not quite) all the known American Nycteribiidae, further remarks on it are deferred to Section III of this paper (p. 495).

BASILIA EILEENAE, sp. n.

Length 1.50–1.75 mm. Colour of the chitinous parts light yellowish-testaceous. *Head* almost bare, except for a series of bristles of moderate length close to the front margin; *eyes* (examined in balsam-mounts under a high power)



FIG. 1.—*Basilia eileenae*, ♀, dorsal aspect (head bent over on right-hand side).

consisting of two facets on a black-pigmented ground. *Thorax* ventrally considerably broader than long (in fig. 2 it appears about $1\frac{1}{2}$ times as broad as long, but the length is actually a little more, though this does not appear, owing to the upward curvature towards the front margin); in the *legs* the broad and laterally compressed form of the tibiae is shown in fig. 1, where these parts are not in quite a natural position.

Abdomen ♂: the basal tergite is only indicated by a transverse series of fine bristles, rather widely spaced, some short, some rather long; tergites 2-6 have the surface bare, in 2-5 the hind margin is set with fine bristles of varying length, but all rather short, except in tergite 5, where some of those in the middle are fairly long, while in tergite 6 the marginal bristles are longer, and four of the median bristles are very long; the anal segment dorsally has a few bristles of moderate length scattered on the posterior half of its surface, and three or four at either hind corner, while rather strong erect bristles of medium length are visible on the sloping sides. Ventrally, the basal sternite has two irregular transverse series of short bristles on its posterior half, and some bristles directed outwards at either side; ctenidium normal, with about forty or more teeth; sternite 2 has a few minute bristles on its surface, and its hind margin set with

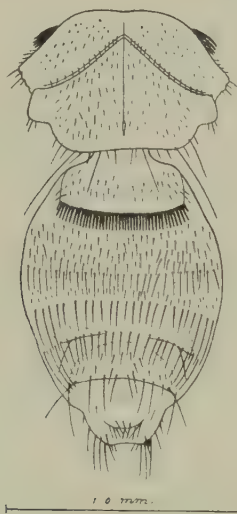


FIG. 2.—*Basilia eileenae*, ♀, ventral view of thorax and abdomen.

bristles of varying length, short and fairly long; sternite 3 has the surface virtually bare except for one or two bristles near either hind corner, and in the marginal series a long bristle on either side is directed outwards; sternite 4 has the surface bare, a transverse series of short bristles just before the hind margin, two or three long bristles (directed outwards) at either hind angle, and several short outstanding bristles on either side margin; but the remarkable feature of sternite 4 is the ctenidium of about twenty-two long and stout teeth, not very close together and not in a regular series, but set irregularly in more than one series, in some cases one in front of the other, the anterior teeth directed mostly ventralwards, the posterior backwards and some of them slightly curved inwards; anal segment with claspers long, slender, tapering, their inner sides

nearly parallel, outer sides slightly curved inwards towards the apex (in fig. 3 the apices of the claspers are shown under sternite 4, as in a transparent preparation).

♀: basal tergite indicated much as in the male; second tergite large, with hind margin arcuate, surface bare, margin rather sparsely set with bristles of varying length, short at the sides, about four of those in the middle very long; between the second tergite and the anal segment the dorsum is mainly membranous, with three tergites indicated; the anterior only by a transverse series of bristles of moderate length, the next by two series side by side, each in a slightly arcuate line forming the hind margin of a feebly chitinised area and each consisting of about four very long bristles and two shorter ones, the posterior by a transverse series, divided in the middle, along the hind margin

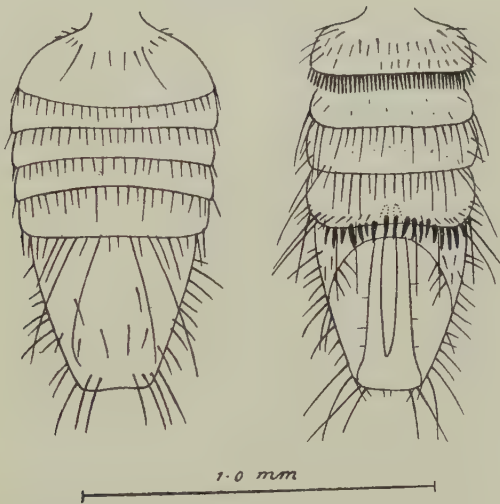


FIG. 3.—*Basilia eileenae*, ♂, dorsal view (left) and ventral view of abdomen.

of a faintly chitinised area, each half of the series consisting of about four very long and several shorter bristles; the surface of the dorsum between these transverse series is bare, but the lateral parts bear scanty and very minute bristles (scarcely visible except in a balsam-mount under a high power) and a few longer ones almost in line with the three transverse series; anal segment with a few very short bristles in front of either hind corner and several erect longer bristles at either corner. Ventrally, the basal sternite is like that of the male; behind this the surface is membranous, segmentation being indicated by three transverse series of bristles of moderate length; between the basal sternite and the first of these series the surface bears rather close short bristles, between the first and second transverse series it is bare in front, but has very short bristles extending irregularly across in front of the second transverse

series, while between the second and third transverse series it is bare except for a few short bristles at the sides ; in the third transverse series of bristles a very short chitinous area is indicated on either side of the middle line ; behind the third transverse series is a large chitinated area, more clearly defined and truncate behind, less clearly defined and arcuate in front, with about eight fairly long bristles at its hind margin and shorter ones scattered on its surface ; behind this lies the subgenital plate, with hind margin arcuate and bearing a rather close group of bristles of moderate length.

Puparium : the single specimen is a little under 1.25 mm. in length, pitchy-blackish, and moderately shining, with surface finely reticulate, transversely striolate at the anterior end. Like the puparia of other species which have been described, it has the ventral surface flattened, and there is a flange or rim round the flattened ventral surface, originating from an exudation of chitin which occurs during the transformation of the larva into a puparium, and which

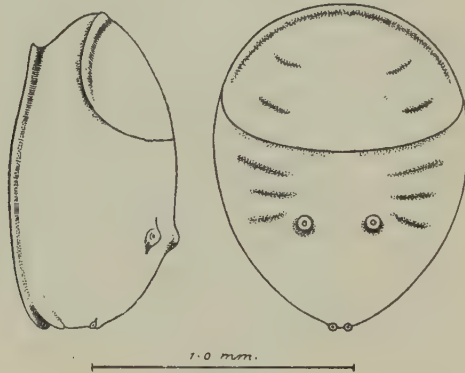


FIG. 4.—*Basilia eileenae*, puparium, lateral and dorsal aspects.

holds the latter fast. This flange is more even and regular than in the puparium of *Nycteribia* (L.) *pedicularia* (which I described and figured, Ent. Monthly Mag. lxx, pp. 256–9, 1934). The puparium of *Basilia eileenae* may also be compared with those of the north American species, *Basilia corynorhini* (see Ferris, Ent. News, xli, pp. 295–7, 1930), and the African species, *Cyclopodia greeffi* Karsch (see Rodhain et Bequaert, Bull. Soc. zool. France, xl, pp. 248–62, 1916). It differs from those of the other species in the manner in which the front end overhangs the ventral flange ; the anterior lateral parts of the curved suture (bounding the portion which is detached when the adult emerges) form a definitely overhanging edge when viewed in profile ; the ventral flange is not visible at all in direct dorsal view, and the curved shadow shown round the anterior end in fig. 4 is due to the front margin of the overhanging portion being somewhat explanate ; the marked elevation of the anterior, and the lesser elevation of the posterior, larval spiracles, are also characteristic. Faint

transverse depressions, probably indicating the larval segmentation, are shown in fig. 4. The flattened ventral surface is, as in other species, less pigmented and more or less translucent in the middle, but the flange itself is as dark as the dorsal surface.

CEYLON: Mousakande Group, Gammaduwa, c. 2,500 feet, from the tube-nosed bat, *Murina eileenae* Phillips; 1931, 1 ♂; 1. viii. 1933, 4 ♂, 13 ♀, 1 puparium. Captain Phillips has told me that the bat is very rare; up to July 1933 he had examined seven specimens, but had only found on them a single Nycteribiid, the male example taken in 1931; but on 1 August 1933 several more specimens of the bat were brought to him, and from these he collected the series of the parasites recorded above. I do not know to what substratum the puparium was attached when it was found.

This species is little like any other known to me. It may best be compared with *Basilina nattereri* (Kol.)*, a species recorded (so far as I am aware) only from Europe, but to which several female examples from Sumatra have been referred by Professor Ferris†. I have seen no male example of *B. nattereri*, but according to Kolenati's description and figures (Horae Soc. ent. Ross. ii, pp. 57-60, pl. vii, 1862) the fourth sternite has only about four horny teeth on the middle of the hind margin, instead of the strongly developed ctenidium so characteristic of *B. eileenae*, and there are other minor differences, the abdomen in *B. nattereri* being on the whole more bristly. I have examined several of the female specimens from Sumatra referred to *B. nattereri* by Professor Ferris, and which agree with Kolenati's figures (l.c.) of the female sex; the second tergite is smaller, and the membranous part of the dorsum behind it is more bristly, than in *B. eileenae*; ventrally, the part of the membranous surface between the first and second transverse series of long bristles is much more bristly than in *B. eileenae*, having about four irregular transverse series of short bristles. According to recorded measurements (Speiser, Arch. Naturg. lxvii, 1, p. 40, 1901) and to the specimens from Sumatra, *B. nattereri* is also a somewhat larger insect than *B. eileenae*.

NYCTERIBIA (ACROCHOLIDIA) PHILLIPSI Scott.

Nycteribia (Acrocholidia) phillipsi Scott, ♀, Rec. Ind. Mus. xxvii, pp. 370-2, figs. 5-7, 1925.

This species was based on several specimens, all of the female sex. After the paper containing the description had gone to press, but before it was published, I received through Mr. R. Senior-White two males collected by Captain Phillips. The figures published here were drawn shortly afterwards by Mr. H. C. Gillings of Cambridge, but I have withheld publication of the

* Originally described as *Nycteribia (Listropodia) nattereri*, subsequently referred by Speiser (1901) to *Penicillidia* and, still later (1908), to *Basilina*.

† See first footnote on p. 496.

figures and of a description of the male sex until now, when other Nycteribiid material from Ceylon is being reviewed.

♂. The characters of the abdomen are sufficiently indicated by the figures. The specimen drawn has a Laboulbeniaceus fungus attached to the left side, on the membrane between the hind corner of the fourth sternite and the anal segment. The constricted appearance of the fifth tergite in dorsal view is due to lateral compression of the specimen in that region, and is not characteristic of the male sex as a whole. In the anterior tergites and sternites the bristles of the marginal series are comparatively short; the basal tergite has a few very minute bristles on its surface, tergites 2 and 3 have very short bristles sparsely scattered on the middle part, in tergite 4 the surface is almost, in tergites 5 and 6 quite, bare. Sternite 4 is produced in the middle of its hind

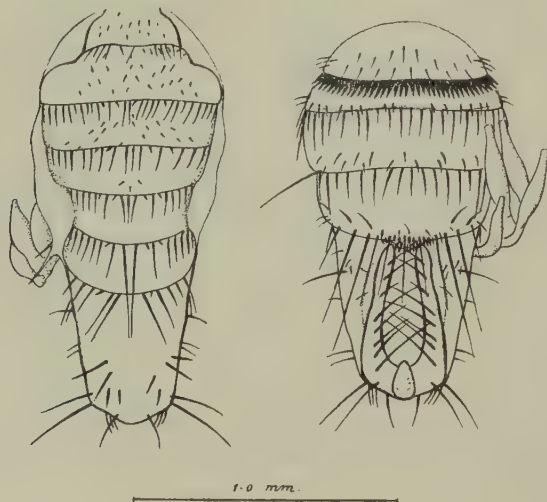


FIG. 5.—*Nycteribia* (*Acrocholidia*) *phillipsi*, ♂, dorsal view (left) and ventral view of abdomen, bearing a Laboulbeniaceus fungus.

margin and bears a group of (roughly) about 20 short black spines, placed irregularly, not in a transverse series, those in front being extremely short, those behind a little longer. Claspers fairly stout, slightly sinuate in the median part of their length, with apices rather blunt.

CEYLON: 2 ♂ from *Rhinolophus rouxi rouxi* Temm., Mousakande Estate, Gammaduwa, East Matale, 3,000 ft., 29. iii. 1925 (*W. W. A. Phillips*). The original female specimens were taken from individuals of the same host-species at Anasigalla, Matugama, about 100 feet, xii. 1921, and a single female was subsequently obtained, from a bat of the same species, at Gonagama, Kitulgala, about 700 feet, 30. vii. 1925. *Rhinolophus rouxi rouxi* is, therefore, the only recorded host-species.

The question of the identity of this species with *N. (A.) blainvillei* Leach, which I discussed in my former paper, must remain open, as I am still ignorant where the type of that species is situated.

The following notes on species already recorded from Ceylon contain certain additional facts regarding distribution, hosts, &c. :—

PENICILLIDIA JENYNSI (Westwood) var. *INDICA* Scott, Rec. Ind. Mus., xxvii, pp. 363–5, fig. 1, 1925.

CEYLON : subsequent to the finding of the specimens recorded in my paper cited, Captain Phillips obtained four males and four females from several specimens of the same host-species, *Miniopterus fuliginosus* Hodgs., at Mousakande Estate, Gammaduwa, East Matale, at altitudes of 3,000 and 3,500 feet, respectively, 30. iii. 1925 and 10. ii. 1926.

The single male specimen taken at the earlier date has the dorsal tergites of the abdomen exceptionally strongly and densely bristled, both on the surface and the hind margins.

The var. *indica* occurs also in INDIA. The typical form of the species has been recorded from CHINA, SUMATRA, and FORMOSA ; also from the PHILIPPINE ISLANDS (Ferris, Philippine Journ. Sci., xxv, p. 400, fig. 7, 1924) and from JAPAN (*teste* Kishida, in the work cited on p. 489, below).

PENICILLIDIA BATHYBOTHYRA (Speiser) ; Scott, op. cit., pp. 365–6.

CEYLON : the following record is later than those in my paper cited ; Kekirawa, N.C.P., about 200 ft., 16. vii. 1933, from *Pipistrellus coromandra* Gray, 2 ♂ (*W. W. A. Phillips*).

Captain Phillips wrote that he had sent no Nycteribiids before from this species of bat. But the host on which *P. bathybothyra* was previously found in Ceylon by J. C. F. Fryer was almost certainly *Pipistrellus coromandra*, as explained in my paper cited, p. 366. Other localities and hosts are recorded in that paper.

NYCTERIBIA (ACROCHOLIDIA) EUXESTA (Speiser) ; Scott, op. cit., p. 369.

The general distribution is : BURMA, CEYLON, INDIA. The specimens from Ceylon recorded previously were taken from *Hipposideros lankadiva* Kel. at Peradeniya (*J. C. F. Fryer*). The following may be added : Gonagama Estate, Kitulgala, at elevations from 200 to 600 feet, respectively, on 11–12. v., 7. vi., and 7. vii. 1925, 3 ♂, 4 ♀ (*W. W. A. Phillips*) ; all taken from bats of the same species, *Hipposideros lankadiva*. One of the male examples bears a Laboulbeniaceus fungus.

This species has been found on bats of the families Pteropodidae (*Rousettus*, *Cynopterus*) and Rhinolophidae (*Rhinolophus*, *Hipposideros*).

NYCTERIBIA (LISTROPODIA) ALLOTOPIA Speiser ; Scott, op. cit. pp. 375–6 ; Ferris, Philippine Journ. Sci. xxv, pp. 397–9, fig. 5, 1924 ; Kishida, Iconographia Insectorum Japonicorum, 1932.

Additional records are the following: CEYLON; Mousakande Estate, Gammaduwa, East Matale, 3,000-3,500 ft., 5. iv. 1925 and 10. ii. 1926, from *Miniopterus fuliginosus* Hodgs., 5 ♂, 9 ♀ (W. W. A. Phillips). The bats were of the same species on which this Nycteribiid had previously been taken in Ceylon; nearly all the Nycteribiids were found on four bats which formed part of a large colony.

To the general distribution of this Nycteribiid, namely, SUMATRA, FORMOSA, CHINA, CEYLON, INDIA, must be added PHILIPPINE IS. (*teste* Ferris) and JAPAN (*teste* Kishida). In the case of Japan, I have not seen specimens, and cannot be quite sure from Kishida's figure, but the determination is probably right.

NYCTERIBIA (LISTROPODIA) PARVULA Speiser; Scott, op. cit. pp. 376-7; Ferris, Philippine Journ. Sci. xxv, p. 399, fig. 6, 1924; Kishida, Iconographia Insectorum Japonicorum, 1932.

The following additional record indicates the abundance in which this species sometimes occurs, and also its frequent association with *N. (L.) allotopa* on the same individual bats. CEYLON: Mousakande Estate, Gammaduwa, 3,500 ft., 10. ii. 1926, from *Miniopterus fuliginosus* Hodgs., 23 ex. (♂♀) (W. W. A. Phillips). The bats were the same four members of a large colony on which the specimens of the preceding species were found.

To the general distribution of this Nycteribiid, namely, SUMATRA, FORMOSA, CEYLON, INDIA, must be added PHILIPPINE IS. (*teste* Ferris) and JAPAN (*teste* Kishida, whose determination is right, so far as I can judge from his figure).

II. DESCRIPTION AND RECORDS OF SPECIES FROM CHINA.

Two of my earliest papers on Nycteribiidae were based on a collection from Formosa*. I am now dealing with material which I have been unable to work out completely before, but which was obtained in 1926 in Shantung Province, China, by Professor Edward Hindle. This collection comprises two well-known and widely distributed species and a third which I at once saw to possess certain very striking characters and which, since I have been unable to identify it with any described species, is here described as *Nycteribia (Achrocholidia) hindlei*, sp. n.

A Chinese writer, Yin-Ch'i Hsü, in a paper entitled 'Two new species of insect parasites of the bat in Soochow' (Peking Natural History Bulletin, ix, part 4, pp. 293-8, one plate, June 1935), quoting from a manuscript catalogue of insects of China, lists four species of Nycteribiidae as occurring in that country. One of these, *Nycteridopsylla galba* Dampf., is not a Nycteribiid, but a flea; the

* Trans. Ent. Soc. London, 1908, pp. 359-70, pl. xviii, and Arch. Naturg. lxxix, Abt. A, 1913, pp. 92-103 (Feb. 1914).

record of another, *Penicillidia jenynsi* (Westw.) var. *indica* Scott, is not quite right, since it was the typical form of this species which was described from China, while the var. *indica* Scott (1925) is, so far as known, confined to India and Ceylon. The records of the other two species are correct: *Nycteribia* (*Listropodia*) *allotopa* Speiser, described from Sumatra, was recorded by me from China (Feb. 1914) and subsequently from Ceylon and India; while *N. (L.) pedicularia* Latr. was recorded from China by me (1925), and a new record from that country is given below. *Penicillidia dufouri* (Westw.) is, so far as I am aware, recorded from China for the first time in this paper. I know of no other species occurring in China.

Yin-Ch'i Hsü has also described and figured, in the work cited, a new species, *Listropodia wui*, but it is unfortunately very doubtful if this can be maintained, as explained below (p. 494).

Moreover, through the same writer my attention was called to the 'Iconographia Insectorum Japonicorum' ('Nippon Konchu Zukan'), a work by many authors published at Tokyo in 1932*. In this book ten species of Nycteribiidae are described and figured, six being well-known species, while four are described and figured apparently as new by Kishida, under the names *Acrocholidia nipponensis*, *Stylidia tarsalis*, *Listropodia pygmaea*, and *Cyclopodia magna* (in the first three, subgeneric names are used as generic). The short descriptions are in Japanese, and I am indebted to a Chinese lady and gentleman, Mrs. C. C. Hu and Mr. P. W. Fang, who read Japanese, for kindly supplying me with translations. Unfortunately both descriptions and figures, though adequate to illustrate a representative series of their country's insects to Japanese readers, are not adequate for certain identification of species when comparison with material found in other parts of the world is required. It is just possible that *Nycteribia* (*Acrocholidia*) *hindlei*, described below, is identical with *N. (A.) nipponensis* Kishida, but the question must remain open.

NYCTERIBIA (ACROCHOLIDIA) HINDLEI, sp. n.

Length 2.5–3.0 mm. Colour of chitinous parts yellowish-testaceous. *Head* bare, except for an anterior submarginal series of bristles, short at the sides, rather longer on the vertex (the absence of eyes has been confirmed by examination of a balsam-preparation under a high power). *Thorax* with ventral plate almost as long as its greatest breadth, somewhat narrowed to the front. *Legs* normal (fig. 8).

Abdomen ♂: the small basal tergite has some very minute bristles on its surface on either side of the middle line, and a marginal series of bristles, the middle ones of which are moderately long; in the region of tergites 3–6 the abdomen is laterally compressed, and the tergites are progressively more produced backwards, so that the anal segment is largely hidden when viewed from above (fig. 6); the surfaces of tergites 2, 3, and 4 are covered with short

* Reference has already been made to this book in the case of several widely distributed species, in the Section on Nycteribiidae occurring in Ceylon, above, pp. 487–8.

bristles except in the middle line and near the side margins, tergite 5 has only a few scattered short bristles on the median part of its surface, and the surface of tergite 6 is bare; the nature of the marginal series is indicated in fig. 6, the bristles on the margins of tergites 2 and 3 being shorter but closer, those on tergites 4 and 5 longer but further apart, while tergite 6 has bristles only on the parts of its hind margin a little on either side of the middle line; some of those

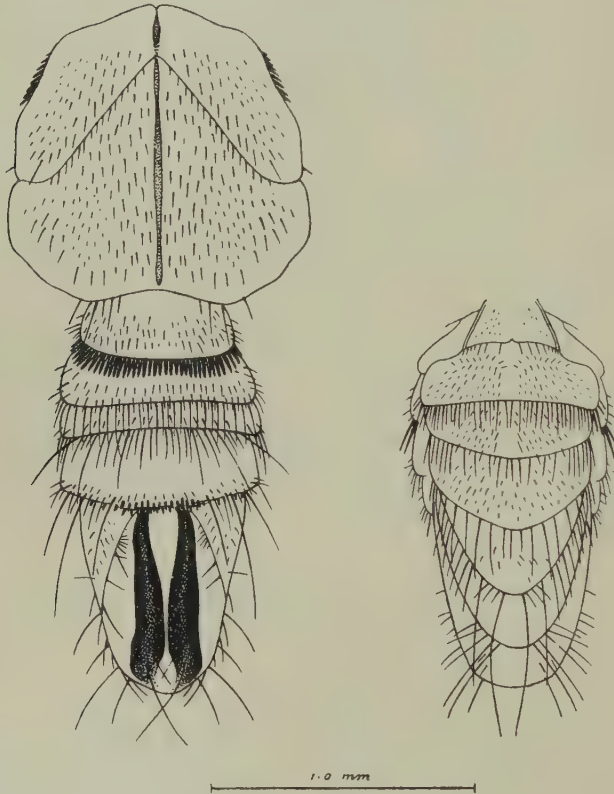


FIG. 6.—*Nycteribia (Acrocholidia) hindlei*, ♂, ventral view of thorax and abdomen (left) and dorsal view of abdomen.

on the hind margins of tergites 5 and 6 are very long; anal segment short and bluntly rounded at the apex, its surface bare except near the hind corners, where there are some scattered moderately long bristles on either side and several long ones at either corner. Ventrally, the ctenidium of the basal sternite is composed of about 50 teeth; sternite 2 has its surface covered with short bristles and a marginal series of bristles of varying length, mostly long; sternite 3 has an irregular transverse series of short bristles on the posterior

part of its surface, and a marginal series of long bristles, three of those on either side being very long, the outer two of the three being erect and directed outwards; sternite 4 is about as long as 2 and 3 together, and bare except for a submarginal series of rather long erect bristles, on the margin there are several very long bristles at either side, and in the median third several rows of short black teeth, which are sparsely continued on either side as a single row; anal segment with claspers very large, stout, and broad, curving outwards towards the apex, and very dark, blackish-pigmented not only at the apex, but through their whole length.

♀: basal tergite as in ♂; tergite 2 large, widely arcuate at the sides, subtruncate in the middle behind, along the mid-dorsal line it is paler and less

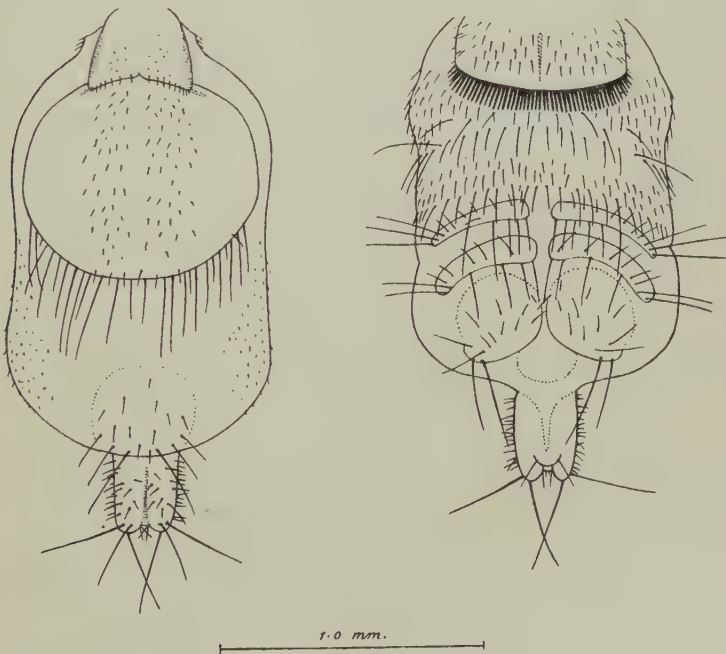


FIG. 7.—*Nycteribia (Acrocholidia) hindlei*, ♀, dorsal view (left) and ventral view of abdomen.

chitinised, on either side of this the surface bears short bristles, while the lateral parts are bare; the setae of the posterior marginal series are of varying length, mostly long or very long; behind this tergite the connexivum is quite bare except at the sides, which bear very short bristles; a chitinous area (not very sharply defined) before the anal segment bears scattered erect bristles, six on its hind margin being long and stout; anal segment narrow, with a median longitudinal groove or depression, and produced slightly at the hind end on either side of the anus; its surface bears numerous short erect bristles, and the

produced portions bear three very long ones apiece. Ventrally, basal sternite as in ♂; immediately behind this the connexivum bears scattered rather short bristles, with several longer erect ones on either side of the middle line, and a transverse series of long bristles behind; the next area of connexivum also bears scattered rather short bristles, and a posterior transverse series of longer ones; behind this are two pairs of curved chitinous plates, long and narrow in a transverse direction, each with a series of erect bristles (in the anterior pair of chitinous plates the outermost three, in the posterior pair the outermost two, are very long) on the surface, and in the anterior pair of plates five, in the posterior pair four, long bristles, directed backwards, on the hind margin; behind these lies a pair of nearly rounded chitinous areas, not very sharply defined, each with scattered bristles on its surface and two very long ones,

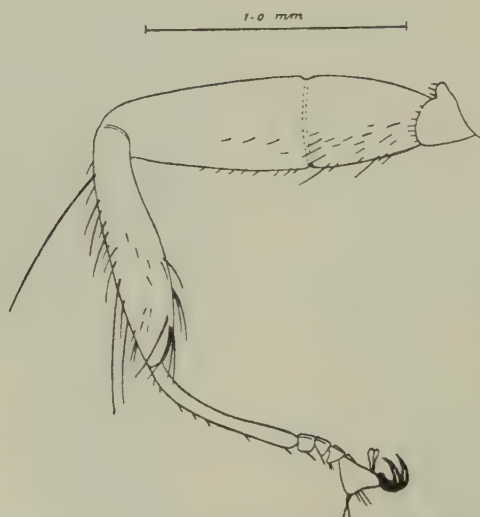


FIG. 8.—*Nycteribia (Acrocholidia) hindlei*, ♂, middle leg, posterior view.

directed backwards, at the outer hind corner; there is an ill-defined bare median chitinous area behind these two areas; ventral side of anal segment with the chitinous part divided in front by a backward extension of the membrane, bare except for some fine bristles, not very long, near the anus.

CHINA, Shantung Province: Tsinanfu, 9. x. 1925, from *Rhinolophus ferrum-equinum nippon* Temm. (Oldfield Thomas det.), 1 ♂, 1 ♀; Tsinan, 2. vii. 1926, from a bat of the same species, 5 ♂, 12 ♀; Lung Dung, Tsinan, 18. vii. 1926, from an undetermined bat, 2 ♀; all collected by E. Hindle.

Type and paratypes in the British Museum, paratypes also in the Molteno Institute, Cambridge.

This is one of the few species of Nycteribiidae in which, contrary to the more usual condition, the most striking specific character is to be found in

the male sex, in the great size and breadth and dark coloration of the claspers ; in *N. (A.) vexata* Westwood these organs are slender, incurved at the apex, and only dark at the apex, otherwise light-coloured. The latter species, distributed over Europe and North-West Africa, is the only one with which *N. hindlei* can be at all closely compared. But *N. hindlei* is a distinctly larger insect than *N. vexata*, more robust and with stronger bristles ; the ventral plate of the thorax is proportionately longer and more narrowed in front ; in the male the teeth on sternite 4 comprise several rows in the middle and others extending in a single row on either side, while in *N. vexata* there are only a few teeth in a single row in the middle of the hind margin. In the female, the differences are as follows : in *N. hindlei*, second tergite much larger and longer, with much longer bristles on hind margin (in *N. vexata* this tergite is small and transverse) ; dorsal membrane quite bare in the middle (in *N. vexata* it bears short bristles) ; chitinous area in front of anal segment rounded, with scattered bristles on surface (in *N. vexata*, a transverse chitinous plate with bristles only on hind margin) ; anal segment narrower, the projecting tubercles on either side of the anus close together, not widely separated as in *N. vexata* ; on the ventral side of the abdomen (♀) the bristles are on the whole longer and stronger, and the boundaries of the two pairs of transverse chitinous plates more definite, in *N. hindlei*. I have used for comparison a male and a female example of *N. vexata* from Eastern Algeria (Hamman Meskoutine, iv. 1913, *P. A. Buxton*).

PENICILLIDIA DUFOURI (Westwood).

Nycteribia dufouri Westwood, 1835.

Penicillidia dufouri Kolenati, 1863 ; Speiser, Arch. Naturg. lxvii, 1, pp. 32-4, 60, 67, 1901 ; Scott, Rec. Ind. Mus. xxvii, pp. 353, 363, 1925 ; J. Gil Collado, Eos, viii, pp. 32, 319, 1932.

CHINA, Shantung Province : Taian, 3. vi. 1926, from *Rhinolophus ferrum-equinum nippon* Temm. and *Leuconoe ricketti* Thomas (bats 81 and 82), 3 ♂, 1 ♀ ; Tsinan, 6. vii. 1926, from *Tadarida teniotus* Raf. (bat 99 A), 1 ♀ ; the specimens from Taian were taken in company with those of *Nycteribia pedicularia* recorded below ; all collected by *E. Hindle*.

I have not tried to give an exhaustive bibliography of this widely distributed species, but only references to recent works in which the distribution is summarised and the hosts are listed, with the addition of references to papers by Gil Collado on the Diptera Pupipara of Spain and Morocco. In my paper cited I summarised the distribution of the parasite and gave a list of the hosts as far as I then knew them. Its known range then comprised many parts of EUROPE and NORTH AFRICA, FORMOSA, and NORTH INDIA (the Himalayas and Kashmir) ; eastern CHINA can now be added, and probably the parasite occurs throughout northern Asia and eastern as well as western Europe. The list of hosts includes several species of *Leuconoe*, *Myotis*, and *Rhinolophus* ; *Leuconoe ricketti* and *Tadarida teniotus* are additions, as is also *Rhinolophus mehelyi carpetanus* (Cabr.), from which Gil Collado has recorded it in Spain.

NYCTERIBIA (LISTROPODIA) PEDICULARIA Latreille.

Nycteribia pedicularia Latreille, 1805.

Nycteribia (Listropodia) pedicularia Speiser, Arch. Naturg. lxxvii, 1, pp. 63, 69, 1901 ;
Scott, Rec. Ind. Mus. xxvii, pp. 354, 375, 1925 ; J. Gil Collado, Eos, viii, pp. 31,
32, 319, 1932.

CHINA, Shantung Province : Taian, 3. vi. 1926, taken (together with the specimens of *Penicillidia dufouri* recorded above) from *Rhinolophus ferrum-equinum nippon* Temm., 7 ♂, 10 ♀ (*E. Hindle*).

As in the case of the preceding species, I have given only references to recent works containing a summary of information regarding the distribution and hosts of *N. pedicularia*, adding references to notes on its distribution in Spain and Morocco. The species is very widespread, and had previously been recorded from CHINA, its distribution also including EUROPE, NORTH AFRICA, NORTH INDIA (Kashmir, Himalayas), FORMOSA, and SOUTH AFRICA. Several species of *Leuconoe* and *Myotis* have been recorded as hosts, as well as *Miniopterus schreibersi* Kuhl., *Rhinolophus hipposideros* Bechst., *Eptesicus serotinus* Schreb., and *Nyctalus noctula* Schreb. I am not aware that the parasite has hitherto been recorded from the species of *Rhinolophus* on which it was found by Professor Hindle.

LISTROPODIA WUI Yin-Ch'i Hsü.

Listropodia wui Yin-Ch'i Hsü, Peking Nat. Hist. Bull. ix, part 4, pp. 295-7, plate, figs. 1-6, 1935.

= partly *Penicillidia jenynsi* (Westw.) and partly *Nycteribia (Listropodia)* sp.

As mentioned above (p. 489), it is unfortunately very doubtful whether *Listropodia wui* can be maintained as a valid species. The specimens figured as the male and female are both males. That figured as *Listropodia wui* male (op. cit., fig. 2) is the male of a species of *Nycteribia (Listropodia)*, probably a well-known species, though neither figure nor description are adequate for sure determination. The example figured as *Listropodia wui* female (op. cit., fig. 1) is the male of a species of *Penicillidia*, probably *P. jenynsi* (Westw.), though the ocelli are not indicated. Meanwhile, a specimen determined as '*Listropodia wui* female' has been kindly sent by Mr. Yin-Ch'i Hsü to Mr. G. B. Thompson, and submitted to me by the latter. It proves to be *Penicillidia jenynsi* (Westw.), correctly determined as to sex, and it differs from typical females of that species only in having a roughly triangular median-posterior area on the second abdominal tergite covered with extremely short, fine bristles, instead of bare, while certain of the bristles on the ventral surface are exceptionally strong. I had already described this variation as occurring in some female examples of *P. jenynsi* (Arch. Naturg. lxxix, Abt. A, 1913, p. 96). It is evident, therefore, that *Listropodia wui* Hsü is a synonym of *Penicillidia jenynsi* (Westw.), and it is probably also a synonym of one of the well-known species of *Nycteribia (Listropodia)* already recorded from the Far East.

III. DESCRIPTIONS AND RECORDS OF NEW WORLD SPECIES.

Genus *BASILIA* Ribeiro.

Basilia Ribeiro, Arch. Mus. Nac. Rio de Janeiro, xii, pp. 177-9, pl. i, 1903; id., op. cit. xiv, pp. 231-2, pl. xxiv, fig. 1, 1907; Speiser, Rec. Ind. Mus. i, p. 296, 1907; id., Zeitschr. wiss. Insektenbiol. iv, p. 244, 1908; Ferris, Ent. News, xxxv, pp. 192-9, pl. iii, 1924; id., op. cit., xli, pp. 295-7, 1930; Schuurmans Stekhoven, Zeitschr. Parasitenkunde, iii, pp. 205-19, 1931; Hase, ibid., pp. 220-57, 1931; Rozeboom, Journ. Parasitology, xx, pp. 315-6, 1934; Curran, Amer. Mus. Novit. no. 765, pp. 1-5, 1935.

Pseudelytromyia Ribeiro, op. cit. xiv, pp. 233-5, pl. xxiii, and pl. xxiv, figs. 2-4, 1907; Ferris, l.c., 1924.

As Ferris has (1924) pointed out, *Basilia* is really distinguished from *Penicillidia* only by the fact that in the former the eyes are composed of two facets, in the latter of a single facet. In the known species of *Basilia*, also, the ventral plate of the thorax is distinctly broader than long. In some species the tibiae are broad and laterally flattened, recalling the subgenus *Listropodia* of *Nycteribia*; this character is exhibited specially by the two Old World representatives of the genus, *Basilia eileenae*, described and figured in this paper (p. 481), and *B. nattereri* (Kolenati), which was originally placed in *Listropodia*. But the broadening and flattening of the tibiae is much less in certain of the American species, namely, *B. ferruginea* Ribeiro and *B. mexicana* (Bigot), while it may be said to be absent in *B. carteri*, described and figured below. Another notable feature presented by some species is the elevation of the chitinous rim of the mesonotum behind into a nearly vertical wall, a condition existing in a less marked degree in *B. carteri* and possibly in *B. ferrisi*, but extraordinarily developed in *B. mexicana*, where it recalls the upturned prow of a boat, and in *B. boardmani*, in which it forms an upright finger-like process.

Pseudelytromyia. I follow Speiser and Ferris in treating this as a synonym of *Basilia*. Two of the three characters on which *Pseudelytromyia* was founded, namely, the presence of three transverse rows of setae in place of four on the lower edge of the tibiae and the longitudinal division of the first visible abdominal tergite in both sexes into two halves (recalling the elytra of Coleoptera, whence the name *Pseudelytromyia*), would scarcely be regarded as generic characters in other genera. Indeed, in certain genera the division of one or other of the tergites actually occurs in some species but not in all. The third character of *Pseudelytromyia* was stated to be the lack of pigmentation in the ocelli. But, while the amount of pigment varies in different species, this character does not appear to separate them clearly into two groups. Professor Miranda Ribeiro, however, wrote to me early in 1928, still maintaining that *Pseudelytromyia* is a distinct genus.

Geographical distribution. As explained below, the small number of Nycteribiidae recorded from North, Central, and South America consists almost, if not quite, wholly of species of *Basilia*. In Europe the genus is represented

by *Basilia nattereri* (Kolenati), originally described (1857) as a species of *Nycteribia* (*Listropodia*), but removed by Speiser first (1901) to *Penicillidia* and subsequently (1908, op. cit.) to *Basilia*. I have examined specimens of *B. nattereri* mounted in balsam, and found the eyes to be quite clearly two-facetted, thereby confirming Speiser's later opinion. In Asia *Basilia* is represented by *B. eileenae* (see above, p. 481) the first authentic representative of the genus recorded from the Oriental Region*. (The Indian species described by Speiser in 1907 (op. cit.) as *Basilia bathybothyra* has since been referred to *Penicillidia* †.)

The geographical distribution of *Basilia*, therefore, seems very curious—a complex of species in North, Central, and South America, with apparently rather isolated outlying congeners in Europe and South Asia. But too much weight should not be attached to it, since additional species may be discovered in the Old World, and the possibility cannot be ruled out that a genus so comparatively slightly separated from *Penicillidia* may have had a polyphyletic origin. It is conceivable that species with the distinctive characters of *Basilia* could originate independently in different parts of the world, in the course of progressive reduction in the number of facets in the eyes. If, however, when further species are discovered, the broad form of the thorax and other characters also prove to be constant, then a polyphyletic origin is more difficult to imagine.

Ferris, in his paper entitled 'The New World Nycteribiidae' (op. cit. 1924), stated that the New World species had been referred to five genera, but that actually only two, *Basilia* and *Nycteribia*, are represented. He referred the greater number of species to *Basilia*. Of the two which he retained in *Nycteribia*, *N. bellardii* Rondani has since been redescribed and placed in *Basilia* (see footnote below, p. 502), while *Nycteribia flava* Weyenberg, described from Argentina in 1881, is unrecognisable from the description, and may well be also a species of *Basilia*. It is possible, therefore, that all the known New World species belong to this one genus. Leaving *Nycteribia flava* out of account, it appears that thirteen species are known from various parts of America. They are shown in the table on p. 497 in chronological order, with their recorded distribution and hosts.

* I have seen some specimens of a *Basilia* from Sumatra in Professor Ferris's collection, determined as *B. nattereri*, but this record has not been published, so far as I know. These examples certainly indicate the occurrence of another species of *Basilia* in the Oriental Region, but whether they are absolutely identical with the European *B. nattereri* cannot be decided at the moment.

† Scott, Rec. Ind. Mus., xxvii, p. 365, 1925. I stated then that I had examined the type-specimen of *Basilia bathybothyra* under the highest power which could be used without detaching the head and mounting it in balsam, and could not recognise the presence of more than one facet in the eye. To confirm the conclusion then arrived at, I more recently (Sept. 1933) detached the head of a male and a female example of this species, preserved in spirit, and mounted the two heads in balsam. Examination under still higher powers leaves no doubt that the eyes consist of a single facet, and therefore the species must be included in *Penicillidia*.

Table of the American species of Basilia.

<i>Basilia bellardii</i> (Rondani, 1878)	Brazil, Venezuela.	<i>Phyllostoma</i> sp., <i>Myotis</i> sp.
— <i>mxicana</i> (Bigot, 1885)	Mexico.	Host unrecorded.
— <i>antrozoi</i> (Townsend, 1893)	New Mexico, California, Texas, Louisiana; Mexico (Lower California).	{ <i>Antrozous pallidus</i> Lec. (and two subspecies, <i>pacificus</i> Morrison and minor Miller). <i>Myotis californicus</i> Aud. & Bach. <i>Corynorhinus macrotis</i> Lec. subsp. <i>pallescens</i> Miller. <i>Nyctinomus cynocephalus</i> Lec.
— <i>ferruginea</i> Ribeiro, 1903	Brazil (Minas Geraes and Rio de Janeiro).	<i>Atalapha frantzii</i> Peters [' <i>Vespertilio aurantius</i> ' , see foot- note on p. 503].
— <i>speiseri</i> (Ribeiro, 1907)	Brazil (Rio de Janeiro).	<i>Atalapha frantzii</i> Peters.
— <i>silvae</i> (Brèthes, 1913) *	Chili (Santiago).	<i>Histiotes</i> [' <i>Vesperugo</i> '] <i>velatus</i> , L. Geoffr.
— <i>corynorhini</i> (Ferris, 1916)	California.	<i>Corynorhinus macrotis</i> Lec. subsp. <i>pallescens</i> Miller.
— <i>forcipata</i> Ferris, 1924	California, Louisiana, New Mexico; Mexico.	{ <i>Myotis californicus</i> Aud. & Bach. subsp. <i>quercinus</i> Grinnell. <i>Myotis thysanodes</i> Miller. <i>Nyctinomus cynocephalus</i> Lec.
— <i>boardmani</i> Rozeboom, 1934	Florida.	<i>Myotis austroriparius</i> Rhoads [= <i>M. lucifugus lucifugus</i> Lec.].
— <i>dunni</i> Curran, 1935	Panama.	<i>Myotis nigricans</i> Wied.
— <i>myotis</i> Curran, 1935	Panama.	<i>Myotis nigricans</i> Wied.
— <i>carteri</i> , sp. n.	Paraguayan Chaco.	<i>Molossops temminckii</i> Burm.
— <i>ferrisi</i> , sp. n. (<i>speiseri</i> Ferris, 1924, nec Ribeiro, 1907).	Costa Rica.	<i>Myotis nigricans</i> Wied.

* See footnote on p. 502.

I know of no published records of Nycteribiidae from the Northern United States or from Canada.

Though the known New World species have been increased by more than half since the publication of Ferris's paper in 1924, the disparity between the number recorded from the Americas and that recorded from the remainder of the world, commented on by Ferris and previously by Speiser and myself, still exists. Probably the proportion is nearly the same, for the list of species occurring in the Old World and Australasia has also been increased since 1924, and amounts to about six times the number recorded from North and South America together. There is every reason to believe that this inequality represents a fact in nature, and is not entirely due to the accidents of collecting.

In the following pages a new species (*Basilia carteri*) is described and figured; another new species (*B. ferrisi*) is proposed for a form which was described and figured by Ferris, but referred by him to *B. speiseri* Ribeiro, from which it is really distinct; the female sex of *B. ferruginea* Ribeiro is redescribed and figured, since only the male sex was fully dealt with previously; and, lastly, *B. mexicana* (Bigot) is redescribed as fully as is possible from the unique and fragmentary type, while the distinctness of this species from others with which it has been supposed to be identical is established.

BASILIA CARTERI, sp. n.

The following description is drawn up from specimens in alcohol :—

Length almost $2\frac{1}{2}$ mm. *Head* with two longitudinal series, each of three setae, on the vertex, the middle seta of each series situated just within the eye; (*eyes* consisting each of two facets on a dark-pigmented ground). *Thorax* with the bristles in the curved dorsal series on either side numbering twelve or thirteen; the mesonotum is elevated posteriorly in both sexes, its chitinous rim forming a nearly vertical wall behind, an approach (though in a less marked degree) to the condition in *B. mexicana* Bigot and *B. boardmani* Rozeboom (see remarks below); ventrally the thorax is considerably broader than long, this is more marked in the female, in which also the anterior corners are more definite, less rounded off, and somewhat upturned. *Legs* (fig. 10) rather long, slender, with the tibiae not markedly broadened or flattened.

Abdomen ♂: a chitinated fold, appearing as a black spot, is visible on either side of the membranous portion at the base of the basal tergite; the posterior chitinated part of this tergite has short setae on its surface on either side of the middle, a little longer towards the hind corners, and a posterior marginal series of longer setae, slightly interrupted in the middle; tergites 2–6 have marginal series of long, and some short, setae, some of those on 4, 5, and 6, on either side of the middle, being very long; these tergites have the surface bare, excepting 2, which has short setae, principally towards the sides, while 2–5 all have very short submarginal setae in the middle; anal segment with short and some long erect setae on its posterior half, and three or four very long ones at either hind corner. Ventrally, the basal sternite has its surface covered with short setae nearly

to the base and a ctenidium consisting of about 58-60 teeth ; sternites 2 and 3 very short, with minute setae on the posterior part of the surface, and rather longer ones right at the sides ; their marginal series consist of fine setae, not very close, of varying length, mostly long, directed backwards, except for some on either side which are erect and directed outwards, while about two on either side of the middle line on sternite 3 are erect and very long ; sternite 4

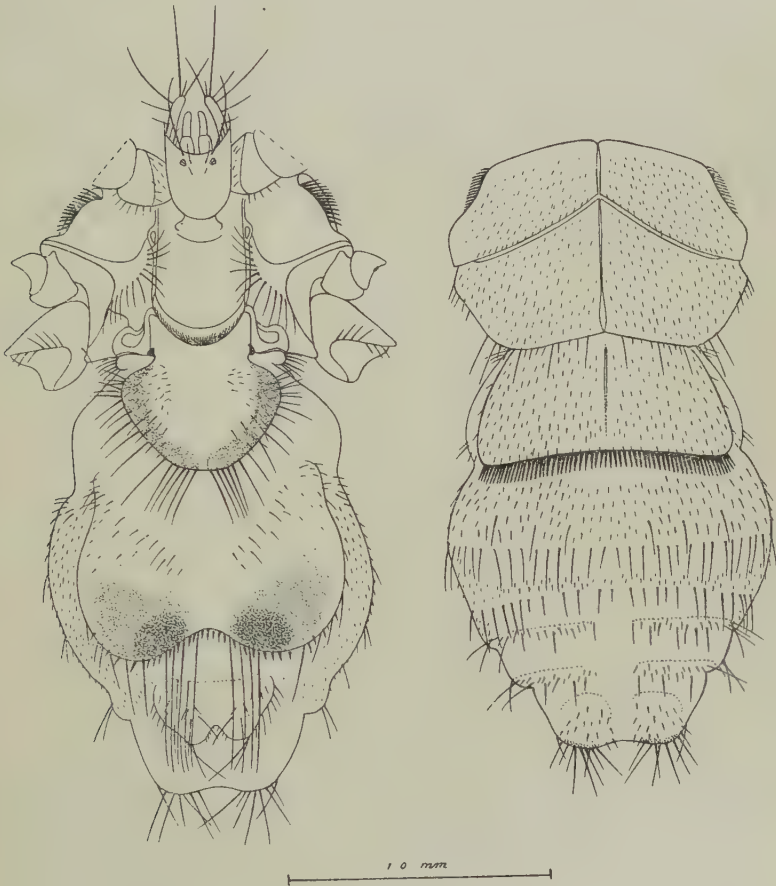


FIG. 9.—*Basilia carteri*, ♀, dorsal view (left) of insect, omitting legs, and ventral view of thorax and abdomen.

nearly as long as the chitinous parts of 2 and 3 together ; with short erect setae on the posterior half of its surface, and very long fine setae (with some shorter ones) close to its hind margin ; the ctenidium occupies about the middle third of the hind margin of this sternite and consists of about 18 teeth, not very close, in two slightly irregular transverse series, those in the anterior series shorter ;

anal segment with numerous short erect setae on its ventrolateral parts; claspers slender, rather dark, nearly black at the apex, tapering and slightly curving inwards, so that the apices are almost contiguous.

♀: basal tergite with a black spot on either side of its membranous base, as in the ♂; this tergite has arcuate sides and narrows to a subtruncate posterior margin; margins rather broadly brown, rest of the surface pale yellowish, whitish along the middle line, where the brown margin is almost interrupted, though the tergite is not divided; there are short erect setae on the surface at either side, longer ones, rather far apart, on the lateral margins, and 10-12 still longer setae in a close series on the posterior margin; behind this the dorsum is occupied by a large transverse tergite with sides arcuate and hind margin sinuate in the middle; it has a band of short erect setae extending obliquely forwards from either side of the middle line, at about the middle

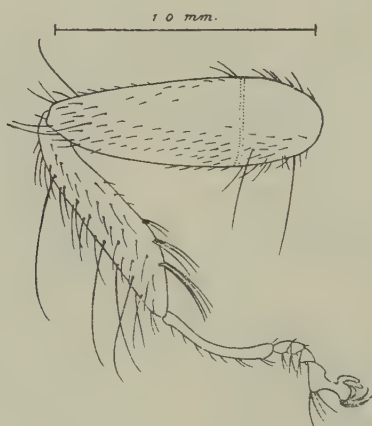


FIG. 10.—*Basilia carteri*, ♀, hind leg, anterior view.

of its length, to the outer front corner, and a few other short setae, on either side, on the surface outside and behind this band; round the hind margin there is a submarginal series of short black setae, closer in the median part, and long setae, rather far apart, on the margin itself, including four or five very long ones on either side of the middle; along the middle line and in front of the oblique bands of short setae the surface is whitish, posteriorly there is a brown chitinous patch on either side, fading in front into pale yellowish; like the basal tergite, this tergite shows signs of longitudinal division, but is not actually paired; lateral connexivum of abdomen closely covered with extremely short setae; behind the large second tergite the anal prominence arises from bare connexivum; the prominence bears erect setae on either side, short at its base and long at its summit; below and behind this prominence projects the hind

end of the abdomen (with the genital opening immediately behind the anal prominence), narrowing slightly, with truncate hind margin and slight median sinuation, surface bare, a group of six or seven longer and shorter setae on the margin at either of the rounded-off hind corners. Ventrally, basal sternite as in the male; behind it, four sternites are indicated (besides the subgenital plate); the anterior two of these are entirely membranous, indicated by posterior transverse series of fine setae of moderate length; the first of the two has its surface covered with short setae, the second (which is shorter) is bare in front, but has short setae forming a narrow band across its posterior part; the next two segments are slightly chitinated and longitudinally paired, their surfaces are bare, but each has a rather irregular series of short and some long setae at the hind margin; subgenital plate also with an indication of longitudinal pairing, with short erect setae on the surface (except near the base) on either side of the middle line, with a little brown patch at the hind margin on either side of the median sinuation, from which patches arise the two groups of setae visible in dorsal view.

PARAGUAYAN CHACO: Makthlawaiya, 20. i. 1927, from *Molossops temmincki* Burm., about 10 specimens, of which I have at present before me 2 ♂ and 2 ♀ (*G. S. Carter*).

Some years ago I sent specimens of both sexes of *B. carteri* to Professor Miranda Ribeiro for comparison with the Brazilian species *Basilia speiseri* (Ribeiro)*. In February 1928 he wrote to me that he considered the two species distinct, *B. carteri* being somewhat larger and presenting many differences. Professor Ribeiro also sent me a female specimen of *B. speiseri* mounted in balsam, and I have this before me now. (I have also before me the series of balsam-mounts of specimens from Costa Rica referred to *B. speiseri* by Ferris†, but I agree with Curran‡ that these belong to a different species, for which the name *Basilia ferrisi* is proposed below.) I am unable to see in the balsam-mount whether *B. speiseri* has the mesonotum elevated behind, but it has the tibiae broader and more flattened, and the thorax ventrally has a more curved outline, with less indication of corners, in front. The principal differences, however, lie in the abdomen of the female; in *B. speiseri* the basal tergite (tergite *b*, or second tergite, according to Ferris) is quite a different shape, and has the setae differently arranged on its surface and its margin; the large transverse tergite (tergite *c* of Ferris) also has the setae on its surface much more numerous and differently arranged; Ribeiro's figure 3 indicates these points correctly. The short minute setae on the lateral connexivum appear more numerous in *B. carteri*. On the ventral surface, comparison is more difficult, owing to the condition of the specimen of *B. speiseri*, but the

* *Pseudelytromyia speiseri* Ribeiro, Arch. Mus. Nac. Rio de Janeiro, xiv, pp. 233-5, pl. xxiii, and pl. xxiv, figs. 2-4, 1907.

† *Basilia speiseri* Ferris, Ent. News, xxxv, pp. 198-9, pl. iii, 1924.

‡ Curran, Amer. Nus. Movit. no. 765, p. 4, 1935.

latter has slightly fewer teeth (about 54) in the ctenidium on the basal sternite ; I cannot trace as many regular transverse series of setae as are shown in Ribeiro's fig. 4 ; the two anterior sternites indicated on the membranous portion are much the same as in *B. carteri*, but the two posterior paired segments, in front of the subgenital plate, are not clearly indicated in *B. speiseri*, the balsam-mount showing instead two irregular transverse groups of moderately long setae, not apparently paired, in the middle part of the abdomen. I have no male specimen of *B. speiseri* for comparison, but Professor Miranda Ribeiro, writing to me in 1928, called attention to differences in the claspers, and these appear in his fig. 2 broader and differently shaped.

B. carteri also differs from *B. ferrisi*, sp. n. (*speiseri* Ferris, nec Ribeiro), in its less dilated tibiae, the quite different shape and different chaetotaxy of the abdominal tergites in the female, in having the basal sternite in the female shorter and the chaetotaxy of the membranous part of the ventral surface of the abdomen different. It may also be compared with *B. dunni* Curran*, a species of which only the female sex is known, and *B. bellardii* (Rondani)†, but is evidently quite distinct from both these species.

BASILIA FERRISI, sp. n.

Basilia speiseri Ferris (nec Ribeiro), Ent. News, xxxv, pp. 198-9, pl. iii, 1924.

Basilia speiseri Curran (nec Ribeiro), Amer. Mus. Novit. no. 765, p. 4, 1935.

In the remarks above, under *Basilia carteri*, I have expressed agreement with Curran in regarding this species as distinct from *B. speiseri* (Ribeiro), and I therefore propose a name for it. Having before me the specimens on which Ferris based his description and figures, and also the specimen of *B. speiseri* (Ribeiro) discussed above, I can confirm that Curran is right in his comments on the differences between the two. Moreover, so far as can be seen in the transparent balsam-mounts, the mesonotum is elevated behind in *B. ferrisi*, as in *B. carteri* ; whether this is so in the true *B. speiseri* (Ribeiro) is, as I have explained, uncertain.

The localities and hosts of the two species are widely different. *B. speiseri* (Ribeiro) was recorded from *Atalapha frantzii* Peters, taken at Quinta de Boa Vista, Rio de Janeiro, Brazil. The specimens of *B. ferrisi* were collected in Costa Rica from *Myotis nigricans* Wied.

* Amer. Mus. Novit. no. 765, p. 3, and figs. 1, 2, 1935.

† Redescribed and figured by Schuurmans Stekhoven, jr., Zeitschr. Parasitenkunde, iii, pp. 206-19, 1931 ; this writer regards *Cyclopodia silvae* Brèthes as synonymous with *B. bellardii* (Rondani), but Curran (op. cit.) considers that, while the description and figures of *C. silvae* make it clear that this species belongs to *Basilia*, they are inadequate for more precise determination.

BASILIA FERRUGINEA Ribeiro.

Basilia ferruginea Ribeiro, Arch. Mus. Nac. Rio de Janeiro, xii, pp. 177-9, pl. i, 1903 (♂); id., op. cit., xiv, pp. 231, 232, pl. xxiv, fig. 1, 1907 (♀); Ferris, Ent. News, xxxv, p. 195, 1924; Curran, Amer. Mus. Novitates, no. 765, p. 2, 1935.

This species was recorded from two widely separated parts of Brazil, Minas Geraes and Rio de Janeiro, from *Atalapha frantzii* Peters ('*Vespertilio aurantius*')*. As Ferris and Curran have pointed out, the description of the male given by Ribeiro in 1903 is accompanied by excellent figures. But only the head of the female was figured, and the abdomen of this sex was not very fully described,

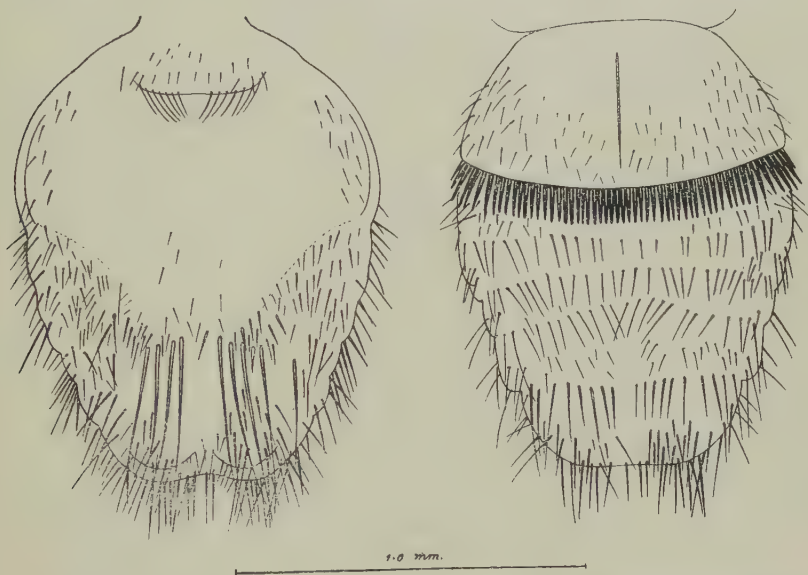


FIG. 11.—*Basilia ferruginea*, ♀, dorsal view (left) and ventral view of abdomen.

in 1907. Consequently it has been impossible to identify the species or to compare it with the other American representatives of the genus. Some years ago (1928), in response to a letter which I wrote to Professor A. de Miranda Ribeiro, I received from the Museum at Rio de Janeiro a slide containing a female example labelled '*Basilia ferruginea*', but without further data. From this specimen the following description and figures have been made.

* In Ribeiro's first paper the host was given as '*Vespertilio aurantius* M. Basil'. But in his second paper (1907, p. 232), Ribeiro explained that this is synonymous with *Atalapha frantzii*, 'the beautiful golden-grey bat which our good and lamented friend, Dr. Manoel Basilio Furtado, had named *Vespertilio aurantius*'. The two names were cited by Ferris as those of two distinct host-bats, but really they refer to the same species, and Mr. Hinton tells me that '*Vespertilio aurantius*' appears to have been overlooked by students of Chiroptera.

I have had some difficulty in making out clearly the characters of the abdomen, but, so far as they can be discerned, they are as follows:—The small basal tergite has a posterior marginal series of long fine setae, apparently interrupted in the middle; the surface bears some very fine short hairs, and two or three longer ones on either side near the margin; no clear lateral margins of this tergite can be seen in the slide. Behind this, the dorsal surface is almost entirely bare of setae to behind the middle; the bare area narrows behind and terminates in two groups of stout blackish bristles, the anterior in each group short, but four of the posterior marginal bristles in each group very long; possibly the bare dorsal area is a paired chitinous tergite, but a definite margin cannot be seen in the slide, being only indicated anteriorly on either side. Behind the two groups of bristles the dorsum again appears bare, then there are two posterior groups of bristles, shorter in front, longer and denser behind, the posterior ones of each group rising from a prominence with a definite outline. On the inner side of each prominence is a transverse group of about four very fine short setae (? on either side of the anus). Below is seen the posterior (subgenital) lamina of the ventral surface, subtruncate behind, with hind corners rounded off and bearing longer and shorter setae. The membranous dorso-lateral and lateral parts of the abdomen are densely covered with longer and shorter setae.

On the ventral side, the ctenidium of the basal sternite consists of about 60 teeth. Behind this there are four transverse series of long setae, rather widely spaced, and segmentation is further indicated at the sides of the abdomen; the surface between these transverse series, and especially that between the ctenidium and the first series, bears some shorter setae. The subgenital lamina, the shape of which has already been described as seen from above, is rather densely setose in its posterior half, the setae near its hand margin being long and several postero-lateral ones on either side directed outwards.

BASILIA MEXICANA (Bigot).

Nycteribia mexicana Bigot, Ann. Soc. ent. France, (6) v, p. 245, 1885.

Penicillidia mexicana Speiser, Zeitschr. Hym. u. Dipt., ii, p. 171, 1902.

Basilis mexicana Ferris, Ent. News, xxxv, p. 195, 1924; Curran, Amer. Mus. Novit. no. 765, p. 4, 1935.

The specimens standing under this name have been in my hands, together with the rest of the *Nycteribiidae* in Bigot's collection, for many years, since they were deposited with me through the kindness of Mr. J. E. Collin, to whom Bigot's collection passed after the death of Mr. G. H. Verrall. The specimens were submitted by Verrall for examination to Speiser, and, as the latter remarked, four out of the five named '*Nycteribia mexicana*' belong to two species of *Nycteribia*. These four consist of: *Nycteribia* (*Listropodia*) sp., 1 ♂, 1 ♀, and *Nycteribia* (*Stylidia*) sp., probably the Palaearctic *N. (S.) biarticulata* Hermann, 2 ♀; thus the second of these two species is not *N. (Acrocholidia)* sp., as stated by Speiser. These four specimens, which were shrunken and very

mouldy, were floated off the two cards on which they were gummed, cleaned, soaked in water, and transferred to alcohol soon after they came into my hands. It is doubtful if any of them was really collected in Mexico.

The remaining specimen, a female, was regarded by Speiser as a true representative of the species *mexicana* described by Bigot, and I have treated it as the type. It was referred by Speiser to *Penicillidia* on the ground that it undoubtedly possessed eyes. But, unfortunately, since that time the head has been lost, and, as the genus *Basilia* had not then been described, it can only now be inferred that the species belongs to *Basilia* from certain characters of the thorax and abdomen. The specimen was very mouldy, and, although cleaned years ago, it was too fragmentary for transference to alcohol, and I carefully gummed the fragments on to a clean card. It is useless to figure the type or redescribe it in detail; but it is to be hoped that fresh material will be found which can be determined by comparison with the type, and the species can then be fully described and figured from fresh examples. It may be added, however, that, judging from the figures and descriptions of other American species, *B. mexicana* is not identical with *B. antrozoi* (Townsend), as was supposed by Speiser, nor with *B. myotis* Curran, which was considered possible by that author (Curran, l.c.); I am doubtful if it is identical with any of the other species, though in some respects it resembles *B. boardmani* Rozeboom (Journ. Parasitology, xx, p. 315, 1934). The mesonotum is raised at the posterior end into an erection (recalling the upcurved prow of a boat), the membranous dorsal surface of which seems to have collapsed; in *B. boardmani* the mesonotum of the female is described as 'prolonged posteriorly as an upright finger-like process'. The abdomen in the type of *B. mexicana* is extremely shrunken, and the basal tergite has collapsed into a concave form; at its posterior margin are two transverse series of seta-bases (the setae themselves being lost) apparently on narrow separate chitinous strips, like those in *B. boardmani*. Nearly all the rest of the dorsal surface of the abdomen is occupied by a pair of long chitinous plates, not unlike those shown in the figure of *B. boardmani*, though longer, but the greater length may be only apparent, due to the collapsed state of the rest of the abdomen; each of these plates has a few short and rather stout bristles on its narrow posterior half (but no bristles are visible on the broader anterior half), and at the apex a group of several short thorn-like bristles and four very long bristles (the latter have become detached and are mounted separately on the card behind the specimen). Little else can be discerned.

The only data given by Bigot were 'Mexique—4 spécim.', without record of host.

The seasons in a tropical rain-forest (New Hebrides). Part 2. Botany.
 By JOHN R. BAKER, M.A., D.Phil., and INA BAKER. (From the
 Department of Zoology and Comparative Anatomy, Oxford.) (Communi-
 cated by Professor E. S. GOODRICH, F.R.S., F.L.S.)

(PLATE 9)

[Read 7 November 1935]

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INTRODUCTION.

This paper is the second of a series in which the work of the Oxford University Expedition to the New Hebrides (Pacific Ocean) is described. The main object of the expedition was to make a detailed study of seasonal phenomena in terrestrial organisms in a remarkably unvarying climate. The meteorological results obtained by the expedition have already been reported (Baker and Harrison, 1936). We wish to acknowledge much help from Mr. T. H. Harrison and Mr. A. J. Marshall in the botanical work. Since it appears that more is known about the causation of seasonal phenomena in plants than in animals, a general discussion of the subject forms part of this paper, although the expedition concerned itself more with animals than with plants.

The observations described in this paper were made in the rain-forest at Hog Harbour (15° 15' S.) in the island of Espiritu Santo, New Hebrides, from September 1933 until August 1934, inclusive. A typical view of the rain-forest is shown in Plate 9, in which one of the photographs represents a part of the forest meteorological station. The forest may also be studied in the frontispiece of a book by one of us (Baker, 1929). The forest covers almost the whole island except the plantation area in the south and south-east and the relatively small areas occupied by the villages, gardens, and deserted garden-sites of the natives. It is not possible to be certain whether

any considerable area of the forest was under cultivation in the past, when the island held a much larger native population. One cannot distinguish a primary and a secondary forest, though the sites of gardens which were deserted within living memory are obvious enough. The forest has the general characters of a typical tropical rain-forest (general luxuriance of foliage, cutting off almost all direct sunlight, together with abundance of creepers, lianas, and epiphytes, and of trees with buttressed roots); but the trees are mostly rather small, and there is not a regular succession of layers of foliage beneath the canopy such as occurs in rain-forests on richer soil. In the vicinity of Hog Harbour the underlying rock is all upraised coral.

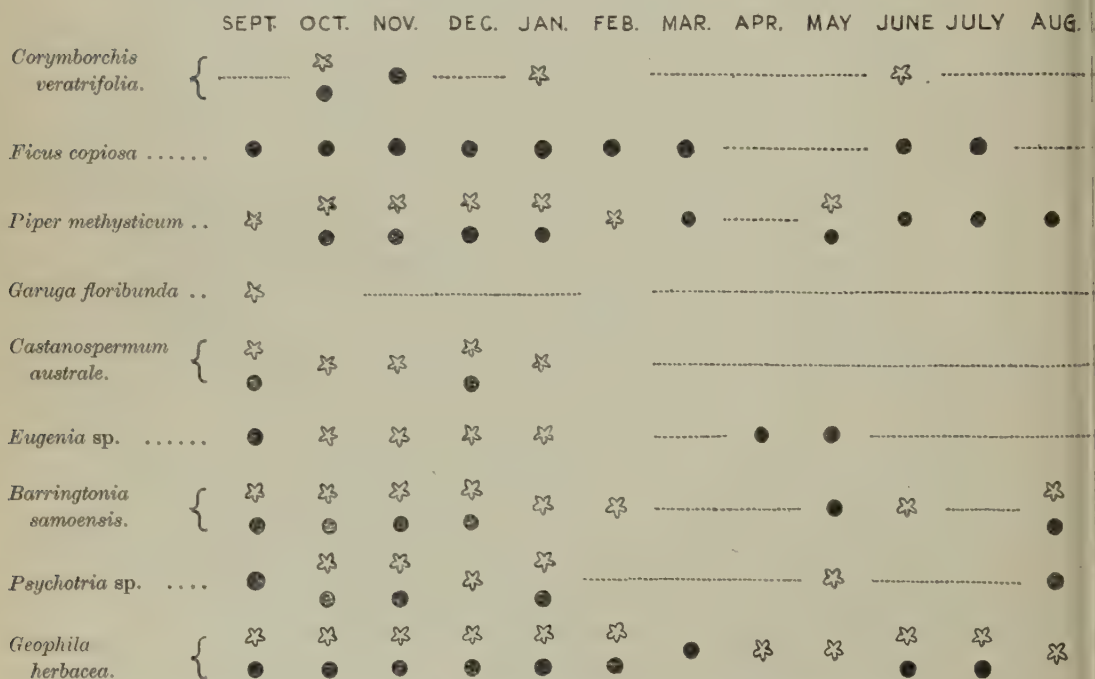


Diagram showing the times of flowering (rosettes) and fruiting (black circles) of the selected species during 1933-4. The dotted lines indicate the absence of flowers and fruit.

Ten species of common wild plants were selected for study throughout the year, in addition to certain cultivated ones. The selected wild plants range from trees to herbs. Observations were made so far as possible between the 10th and 20th of each month, except that in September 1933 they were made late in the month, and in February records were unfortunately not made for four of the species. Observations were confined to specimens of the ten species growing in the vicinity of Hog Harbour. Each month it was noted whether there were expanding flower buds, flowers, unripe fruit, or ripe fruit.

The results of the investigation are shown diagrammatically on p. 508. The five-lobed symbols indicate that flowers (not flower-buds) were observed, and the black circles represent fruits (unripe or ripe). The dotted line indicates that neither flower nor fruit was seen, although the plants were observed. When for any reason observations were not made, a space is left in the diagram.

The climate during the year of the investigation has been discussed in detail in the first paper of this series (Baker and Harrison, 1936). Speaking generally, the climate is a remarkably unvarying tropical one. There is no dry season. Five consecutive months (June to October) are, however, considerably less wet, as well as a little cooler, than the rest. This is clearly shown in the hythergraph, fig. 2 B in the paper by Baker and Harrison quoted above. In the year of the investigation (September 1933 to August 1934) the climate conformed on the whole to the usual regime, except that April and May, usually very wet months, were not nearly so wet as usual. At the forest meteorological station April was the hottest month and July the coolest, but there was only a difference of 2.4° C. (4.3° Fahr.) between the mean temperatures of these two months.

We wish to thank the Keeper of the Department of Botany at the British Museum (Natural History) for arranging for the identification of the plants. This was carried out by Mr. J. E. Dandy, Mr. A. W. Exell, and Dr. G. Taylor, to all of whom we are much indebted. Mr. J. S. L. Gilmour also gave helpful advice.

This study of seasonal phenomena was made under grants from the Royal Society and the Percy Sladen Memorial Fund.

RESULTS.

One of the ten species chosen for special study was unfortunately indeterminable, because no flower nor fruit was seen during the course of the year. This is all the more remarkable because the herb in question (the 'Nasukonru' of the natives) is probably the most abundant Angiosperm in the northern New Hebrides. Nearly everywhere it forms the dominant species in the undergrowth (Plate 9, N.). It is a Dicotyledon having long lanceolate leaves with a distinct vein running close to the margin. It grows about two feet high. The natives, who are keen naturalists, state that they do not know the flower of this species. Flower-buds were observed by one of us on one occasion in the high mountains of western Espiritu Santo, but the specimen has been mislaid. The remaining nine species will now be considered in turn.

1. *CORYMBORCHIS VERATRIFOLIA* (Reinw.) Bl. (Orchidaceae).

Native name : 'Nerē vudhvēkar'.

This is a herb with stiff pointed leaves and small white flowers. There appear to be three flowering seasons in the year—in October, January, and June. Expanding flower-buds were seen in the months preceding the October and June seasons.

2. *FIGUS COPIOSA* Steudel (Moraceae).

Native name : 'Nedhelagh'.

This species is a smallish tree which bears spherical figs in dense clusters springing directly from the trunk. In the diagram the presence of figs is indicated by the symbol for fruits. Figs were not observed in April, May, and August, and some trees were bare of fruits in December. As not many of the trees of this species were under observation, it is possible, and indeed probable, that specimens with figs might be found at all times of the year. According to the natives, the figs are eaten by fruit-bats, whose breeding seasons will be considered in the next paper in this series.

3. *PIPER METHYSTICUM* Forst. f. (Piperaceae). (Wild Kava.)

Native name : 'Nevülko'.

This is a plant growing about three feet high with cordate divergently-veined leaves (Plate 9, *Pi.*) and minute white flowers growing on fleshy spikes three or four inches long. The fruits are red. As will be seen from the diagram, fruit or flowers were seen in every month except April, and expanding flower-buds were noted in that month. Some plants devoid of fruit or flowers were noted in February and March. It appears that this species reproduces all the year round. This is not surprising, for even so far south as New Zealand the representative species (*P. excelsum* Forst.) is said to flower during most of the year (Cheeseman, 1906).

4. *GARUGA FLORIBUNDA* Decne. (sensu H. J. Lam) (Burseraceae).

Native name : 'Nalü'.

This appears to be the only indigenous tree of Espiritu Santo that is regularly deciduous every year at about the same time, though a few other species cast all their leaves at intervals, which may be regular (see below, p. 513). Early in September (i.e. towards the end of the less wet season) it is almost completely devoid of leaves (Plate 9), and gives a remarkable appearance, showing up vividly against the mass of green when the rain-forest is viewed from a boat at sea. Later in September the flowers are formed at the tree-tops at the same time as the first leaves. The fruits, being inconspicuous, unfortunately largely escaped our observation, and though we have one specimen in alcohol we have no record as to the month in which it was procured. This is the most strikingly seasonal plant in this peculiarly unseasonal climate.

According to Lam (1932) the genus *Garuga* is adapted to a climate which has a rigorous dry season. It is remarkable that it should retain its deciduous nature in the northern New Hebrides, where no part of the year is dry except under exceptional circumstances. Lam states that *Garuga floribunda* generally flowers in the dry season throughout its range. He gives September and October as its flowering season in Celebes, July to November in Java, and March to June in the Philippines. Broun (1912) says that in the Bombay Presidency *Garuga pinnata* is one of the trees most affected by failure of the monsoon

rains, probably owing to its roots being superficial. According to Troup (1921), the leaves of *G. pinnata* start falling in India in November-January, and the tree remains leafless till March-May.

5. *CASTANOSPERMUM AUSTRALE* A. Cunn. (Papilionaceae).

Native name : ' Nās '.

This is a large tree with bright red flowers which principally attract attention when they have fallen to the ground beneath the tree, it being almost impossible in the dim light of the forest to see them at the great height at which they are produced. The fruits are huge woody legumes which are also only easily observed when they have fallen to the ground, and as they are of a very durable nature it is difficult to know when they are freshly dropped. As will be seen from the diagram, the flowering of this tree is definitely seasonal and takes place from September to January, that is, mostly during the warmer wetter part of the year. Expanding flower-buds were, however, seen in July. Some specimens of this species were cut down and transverse sections of the stem were polished to show growth-rings. The latter were found to be clearly marked, and one would not have guessed that they had been formed under such remarkably unseasonal climatic conditions. As Wright (1905) says, ' rings of growth are not, in all cases, . . . a guarantee of the existence of a climatic periodicity '.

6. *EUGENIA* sp. (resembling *E. javanica*) (Myrtaceae).

Native name : ' Nē '.

This ' rose-apple ' is a small tree with smooth, thick, shiny, lanceolate leaves and flowers with numerous magenta stamens. The flowers are borne in clusters of three or four blossoms. All the flowers on one tree come out at one time, and present a very vivid appearance for a few days. The fruits superficially resemble apples and are edible. Mr. Exell tells us that the flowers are very like those of *E. javanica* Lam., but since the leaves are cuneate at the base instead of cordate, and the fruits larger and edible, it is probably a new species. There appears to be a non-fruiting season during the cooler months (June to August). During the rest of the year it is usually possible to find a tree with expanding flower-buds, flowers, or fruits. The natives report that the flowers and fruit are eaten by fruit-bats. The common Australian species of *Eugenia* flower in the Australian spring and summer (Sulman, 1913). The only species in New Zealand flowers from March to May (Cheeseman, 1906).

7. *BARRINGTONIA SAMOENSIS* A. Gray (Lecythidaceae).

Native name : ' Narodh '.

The inflorescence of this tree is very striking, as the white many-stamened flowers, measuring about two inches across, are borne on drooping panicles about a foot long. The kernels are edible. Except during March and April, expanding flower-buds, flowers, or fruits were found in every month. This

behaviour contrasts strongly with that of *B. acutangula* Gaertn. in India, where the flowers appear chiefly from March to May. In 1927 one of us brought back from Hog Harbour some wood of *B. speciosa*, which is remarkable for the poor development of growth-rings. Polished specimens were also prepared of the wood of eight other species of trees from Hog Harbour, namely, *Calophyllum inophyllum*, *Castanospermum australe*, *Cerelea odollam*, *Cordia subcordata*, *Glochidion ramiflorum*, *Hernandia peltata*, *Spondias dulcis*, and *Tournefortia argentea*. Of all the nine species, *Hernandia speciosa* was the one whose wood exhibited least signs of periodical growth. Most of our wood specimens are in the keeping of Professor A. C. Seward at Cambridge.

8. *PSYCHOTRIA* sp. (Rubiaceae).

Native name : ' Yalyalra '.

This is a bush growing to three or four feet high, with smooth green leaves two or three inches long (Plate 9, *Ps.*). The small flowers are borne in insignificant clusters. The fruits are green when first produced, turning red when ripe. Flowers and fruits are frequently seen on the same shrub, and indeed on the same cluster at the same time. (Another species of *Psychotria*, the ' Kerkera-rodh ' of the natives, is very similar, and indeed certain members of the expedition found it difficult to distinguish between them.) There appears to be a long flowering and fruiting period from August to January, and a very short one in May.

9. *GEOPHILA HERBACEA* (Jacq.) K. Schum. (Rubiaceae).

Native name : ' Nidhvura '.

This is a small herb about two inches high, with star-like white flowers and red berries. The leaves are cordate and grow close to the ground with the flowers and fruit standing up slightly above them. As will be seen from the diagram, the one month in which no flower was seen was March.

It will be seen from the diagram that there is a very definite reproductive period from September to January. The start of this long reproductive period coincides with a slight rise of temperature after the end of the cooler period of the year. The rainiest months occur during this period. All the plants under observation had either expanding flower-buds, flowers, or fruits in September and October, and with the exception of *Garuga floribunda* and *Corymborchis veratrifolia* (on which no flower nor fruit was observed in December), all the plants had flowers or fruits until January. The records are unfortunately very scanty for February, but by March none of the plants studied were in flower, and only three were bearing fruit. In May and June there appears to be another general flowering and fruiting period, but this time it occurs when the rainfall is low and the temperature falling. This short reproductive period was over by July. In this month *Geophila herbacea* was the only one of our selected plants in flower. In the rain-forest of Bolivia, at a place in almost the same latitude as Hog Harbour, Rusby (1933) found that February and March were months of special bloom.

Although *Garuga floribunda* stands out as the most obviously and regularly deciduous tree in the northern New Hebrides, yet there are others which lose most of their leaves at one time or nearly at one time. Thus a specimen of *Pterocarpus indicus* Willd. (Papilionaceae) at Hog Harbour was observed to be shedding its leaves rapidly on 23 January 1934, and on the 26th most of its branches had only got new pale green leaves, though some of the branches still retained the old leaves. At Singapore *Pt. indicus* changes its leaves annually about the beginning of the less wet part of the year (February and succeeding months), and Holttum (1930) mentions that certain branches change their leaves before others. In India (Troup, 1921) this species is leafless or nearly so towards the end of the cold season. It thus appears that north of the equator (India), on the equator (Singapore), and south of the equator (Hog Harbour), the leaf-changes occur about the first quarter of the year. According to Lely, *Pterocarpus erinaceus* is leafless at about the same time (December to February) in northern Nigeria.

Spondias dulcis Forst. (Anacardiaceae), a tree with large yellow edible drupes, is said by the natives to cast its leaves periodically. Our wood-specimens show well-marked growth-rings. The fruit of this species was ripe towards the end of January. *Spondias mangifera*, according to Wright (1905), is deciduous during the dry season in the northern forests of Ceylon. In India (Troup, 1921) this tree is leafless longer than almost any other forest tree, and, rather remarkably, ripens its fruit about the same time (December–February or December–March) as its relative at Hog Harbour. In the New Hebrides the banyans cast their leaves periodically, but according to our friend Mr. T. R. ff. Salisbury, who has lived at Hog Harbour as Government Agent for many years, the period is not annual. The natives state that *Terminalia Catappa* L. (Combretaceae) is deciduous at Hog Harbour. This species is annually deciduous in India, and also when grown in southern Florida (Stevenson, 1933), while it changes its leaves twice a year in Ceylon and at Singapore, and twice and sometimes three times a year on the Gold Coast. Thus it is clear that certain trees have such a strong inherent tendency to periodical loss of leaves that they remain deciduous even in the remarkably non-seasonal environment of Hog Harbour.

Two of the natives' chief foodstuffs, the yam and the sweet potato, are planted annually. Seasonal changes in climate are so little obvious that the reckoning of peoples' ages in years is unknown (except in the Christian villages). We therefore questioned them as to how they know when to plant these crops, and discovered that they wait for the flowering and fruiting of certain wild trees. Yams are planted when *Erythrina indica* Lam. (Papilionaceae) flowers, which happens about October. (The same species flowers in April–May in India.) With the co-operation of our friend the Rev. W. Anderson, the experiment is being tried of planting yams at precisely the 'wrong' period of the year—that is, six months after the flowering of *Erythrina*. Sweet potatoes are planted by the natives as soon as the fruit of *Alphitonia zizyphoides* A. Gray (Rhamnaceae) is formed, about the beginning of September.

Monthly observations were made on four cultivated plants, viz. the banana, papaw, bread-fruit, and orange.

Ripe bananas were available in every month of the year, and flowers were seen in September, October, January, May, June, and August. They constitute a favourite food of the fruit-bats.

Bread-fruit in an unripe condition were visible on the trees at all times of the year, except that many trees were devoid of fruit in June. They only ripened during September, October, November, December, January, April, and a few in June.

Oranges in an unripe state were on the trees in large numbers in September. One or two ripe ones were seen during the ensuing months, and these became more frequent in February and March until a climax was reached in April, when all the fruits on the trees ripened and fell off. In May the trees were devoid of flowers or fruit. In June flower-buds and flowers were seen, which had formed fruit by the following month; and the ripening cycle then began once more. Oranges are the only cultivated plants with a strongly marked annual reproductive season that we had under observation.

We should be very grateful to residents in any part of the world, especially the New Hebrides, who would send us further information about any of the species mentioned in the preceding part of this paper. Letters should be addressed to Dr. John R. Baker, University Museum, Oxford. Exact dates are greatly preferable to general statements.

DISCUSSION.

General remarks.—As was stated in the introduction, it appears that botanists have paid far more attention than zoologists to the causation of seasonal phenomena, and it is for this reason that it is appropriate to make a general discussion of the subject in the botanical part of this series of papers.

A review of what is known on the subject makes it probable that many plants have an inherent tendency to flower and sometimes to lose their leaves at fairly regular, often approximately annual, intervals. Environmental influences can also affect flowering and the loss of leaves. In some species the inherent tendency is of great importance, in others the environment. This is well shown by contrasting leaf-fall in two species, teak (*Tectona grandis*) and *Bombax malabaricum*. Coster (1923) remarks that in East Java, where there is great seasonal periodicity in rainfall, teak is much influenced in leaf-fall by climatic irregularities, while the leaf-fall of *Bombax* is scarcely affected. In exact correspondence with this, Holttum (1930) finds that in the much less seasonal climate of Singapore teak trees are never bare of leaves, while *Bombax* retains its long resting period. Thus we have here one species in which the environment is particularly important, and another in which inherent tendencies dominate. But, before these two causes of periodic phenomena are discussed, it will be well carefully to distinguish an allied, but separate, subject—namely, gregarious flowering.

Gregarious flowering.—It is well known that several species of plants exhibit this remarkable phenomenon, in which all the individuals of one species over a wide area tend to flower at the same time. This applies, for instance, to species of *Strobilanthes*, especially *S. sexennis* Nees, in Ceylon (Petch, 1924). This flowers at intervals of about twelve years in any one place and the flowering areas are very large, for the species forms the predominant part of the undergrowth in the up-country jungles. One series of areas flowered in 1917–18 and another series in 1922–3, and in each of these areas flowering had taken place at intervals of twelve years since the middle of the nineteenth century. When the seeds have ripened the bushes die, and twelve years later the new bushes, derived from those seeds, are old enough to flower. Other species of the genus exhibit the same cycle, and at least one species a shorter one. Similarly, according to Petch, the Talipot palm (*Corypha umbraculifera* L.) has an inherited tendency, not very easily influenced by the environment, to flower at a certain age. It is important to stress that this phenomenon is not the same as periodicity in reproduction within the individual, which is the main subject of the study described in this series of papers.

The influence of the environment on reproductive and leaf-fall seasons.—Schimper (1903) reaches the general conclusion that, in those tropical regions in which there is no actually dry season, the plants tend to flower especially in the less wet part of the year (though many flower all the year round). Schimper's conclusion, which does not tally with our results from Hog Harbour, appears to be true of Java as a whole, but it is to be regretted that in his analysis he did not separate the plants of East Java, which has a dry season, from those of West Java, which has not. In West and South-west Ceylon, where there is no actually dry season, it is true that relatively few plants flower during the wettest months (May and October–November); though it must be admitted that the figures show no close correlation between scarcity of rainfall and the number of species flowering. Leaf-fall in Ceylon, however, is directly connected with climatic changes, for it takes place especially in the hot dry season (January–March at Peradeniya).

Wright (1905) concludes that it is probably lack of water to replace that lost by transpiration that induces leaf-fall in the tropics, and this agrees with our finding that the most obviously deciduous tree of Hog Harbour, *Garuga floribunda*, is without leaves during part of the less wet season of the year. Wright dismisses the small temperature changes in Ceylon as unimportant. Holttum (1930) states that at Singapore most trees that change their leaves once a year do so about February–March, i.e. at the beginning of the less wet season. Schweizer (1932) says that application of artificial fertilizers to *Hevea brasiliensis* may delay leaf-change by four or five weeks, and that trees at 500–600 metres tend to be later than those at sea-level. That the environment can directly affect the time of reproduction is also rendered likely by the widely-accepted view that a shower of rain hastens the flowering of coffee. Again, every gardener knows that in some species warm spells early in the year encourage early flowering, as does transplanting in other species.

In addition to this observational evidence, there is direct experimental evidence based on laboratory research, such as that provided by Tincker (1924) on the effect of light. Tincker subjected various plants to daylight for 6, 9, and 12 hours daily, the controls receiving the full period of normal daylight. Equal soil and temperature conditions were provided for all, so far as possible. With the majority of the species investigated, longer exposure to light encouraged earlier flowering (e.g. certain clovers and many grasses). With two species (a *Chrysanthemum* and a runner bean) limitation of light produced earlier flowering. With only one species (a grass, *Poa annua*) the length of the daily exposure to light did not affect flowering.

The effect of internal rhythm.—There is also much evidence of an inherent tendency in plants to show periodic phenomena. We propose, throughout this series of papers, to use the term 'internal rhythm' to indicate a tendency on the part of any plant or animal to behave rhythmically in relation to reproduction (and leaf-fall, in the case of plants) independently of the environment. The evidence for the existence of an internal rhythm in plants may now be briefly reviewed.

Wright states that only three species are evergreen in the wet districts of Ceylon and deciduous in the dry, and that some species undergo defoliation at approximately the same time all over Ceylon, despite the climatic differences. Again, individual specimens of certain species, growing close together, may have somewhat different times of leaf-fall. Wright concludes that 'in many tropical areas the internal factors are responsible for many phases of the vegetation'. Holttum makes the very important statement that in a number of species at Singapore the leaf-change takes place at periods which are not annual nor aliquot parts of a year, and that different individuals of these species may differ in their times. Similarly, Smith (1923) states that an individual of *Breynia cernua* Muell. Arg. at Buitenzorg has changed its leaves at intervals of about $5\frac{1}{2}$ months for eleven years. The leaf-fall has thus happened at various times of the year. Holttum makes the following very illuminating remark, which bears upon much that we shall have to say when we write of the breeding seasons of animals at Hog Harbour:—'In Singapore the climate is such that there is never a time when the heat or drought is so intense that a tree cannot carry leaves; therefore trees which have a natural tendency to a leaf period which is not annual have a free scope to display their peculiarities, which are kept in check in countries which have strongly seasonal climates'.

An important contribution to the literature of seasonal phenomena has been made by Schweizer (1932), who studied leaf-change in the rubber tree, *Hevea brasiliensis*, at Djember in Java. He came to the general conclusion that an internal rhythm is the important factor controlling the time of leaf-change, though certain environmental conditions affect it. In seedlings of this tree, new leaves are rapidly produced at certain periods only, and these flush-periods are separated by different times in different seedlings. If, however, cuttings are taken from a single tree and planted, they show a remarkable uniformity

in their leaf-flush periods, wherever they may be planted. Thus there appears to be an inherent rhythm of flushing. As the plants grow into trees, the periods between the flushes grow longer, until they generally become annual. That the internal rhythm is still retained is shown by observations on cuttings which were taken from single trees and distributed over Java and Sumatra. It was noticed that cuttings from certain trees tended to have their leaf-changes early, those from other trees tended to have theirs late, while those from yet others had them at irregular periods; and the periodicity agreed with that of the individual trees from which the cuttings were taken (for certain individual trees always change their leaves early (May-June) and others late (August)). It may be mentioned that Wright similarly found that cuttings of *Erythrina indica* sometimes retain the leaf-fall period of the tree from which they were taken. Schweizer carried out the experiment of stripping rubber trees of their leaves three or four months before they would normally fall, and noticed that the new ones which are formed fall nevertheless at the time which is usual for the tree concerned, although they are only three or four months instead of nine months old. This, however, cannot in itself be regarded as strong evidence of an internal rhythm. Schweizer says that there is evidence that in other species (*Poinciana regia* and *Lagerstroemia* sp.) there are different stocks, each of which changes its leaves at its special time.

Karmarkar (1934) has shown that in the apple the amount of water in the wood and bark of the current season's shoots rises during the swelling of the buds and flowering, reaching a maximum in June. The amount of nitrogen (whether total nitrogen or protein nitrogen is considered) shoots suddenly up to a peak in June. The normal seasonal cycles in water and nitrogen-content is uninfluenced by manuring in spring with sodium nitrate. Miss Smythe (1934) shows that in the same species there is a seasonal rhythm in the amount of sugar, starch, cellulose, and lignin in the current season's shoots, and this again is unaffected by a spring dressing of sodium nitrate.

Although such strong evidence has been brought forward for the existence of internal rhythms, yet we wish to stress that there is no possibility that annual phenomena can be *wholly* controlled by them in any species of plant or animal. It has been suggested, in so many words, that as the pituitary gland functions as a sort of compensated clock in controlling the oestrous cycles of Mammalia, so also it might be thought to control breeding seasons without the necessity for the environment to act like the finger of the owner of the clock in occasionally putting it right. This idea, however, only requires to be thought out in detail to be rejected. If in any plant or animal there were an internal rhythm controlling an annual cycle, and if this rhythm were incorrect even to the minute extent of six minutes in the year, then if it were breeding in the the spring at the end of the last glacial epoch in the northern hemisphere it would be breeding at precisely the wrong season of the year (autumn) now! Despite this, nearly all birds in Britain do breed between late winter and summer, and none has a special breeding season in the autumn

or early winter. Now it is absolutely inconceivable, from what is known in general about the time-factor in biological reactions, that any organism could have an internal rhythm exact to a few minutes in a year, and we are therefore forced to the conclusion that in temperate countries the environment from time to time 'puts the clock right', to use the simile that we have employed above. In a relatively unvarying climate, where it is not impossible for flowering or breeding to occur at any season, there may be nothing to put the clock right, and then *nearly* annual internal rhythms may be disclosed.

SUMMARY.

1. In the relatively unvarying climate of the northern New Hebrides (about 15° S. in the Pacific Ocean), most of the plants studied present seasonal reproductive phenomena.

2. There is a tendency for plants to flower and fruit from September to January or February and again in May and June.

3. The start of the longer flowering season coincides with the rise of temperature after the end of the cooler period of the year. The rainiest months of the year occur during this long flowering season.

4. Two of the plants studied—namely, the herb *Geophila herbacea* and the shrub *Piper methysticum*—reproduce throughout the year, and possibly the same applies to the tree *Ficus copiosa*.

5. The natives rely upon the flowering and fruiting of certain wild trees to determine the time for planting certain crops (yams and sweet potatoes).

6. Of the cultivated perennial plants, the bread-fruit and orange are seasonal, while the banana and papaw produce fruit throughout the year.

7. Seasonal phenomena in reproduction and leaf-fall depend partly on an internal rhythm and partly on the environment, and in the interplay of these two controlling factors the one dominates in some species, the other in others.

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2



3



4

Photographs by Zita Baker

PL. 9. — GARUGA FLORIBUNDA, LILL. near

Figs. 1 & 2, GARUGA FLORIBUNDA
Figs. 3 & 4 TYPICAL VIEWS OF THE FOREST UNDERGROWTH

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EXPLANATION OF PLATE 9.

Fig. 1. *Garuga floribunda*, photographed on 9 September 1933.

Fig. 2. The same tree, photographed on 23 September 1933.

Figs. 3 & 4. Typical views of the forest undergrowth. Fig. 4 represents part of the forest meteorological station.

K., katathermometer, hanging in the position in which readings were taken daily.

N., 'Nasukonru'.

Pi., *Piper methysticum*.

Ps., *Psychotria* sp.

A new genus of fossil deer from the Miocene of Africa. By D. G. MACINNES.
(Communicated by Dr. G. P. BIDDER, F.L.S.)

(With 5 Text-figures)

[Read 2 April 1936]

INTRODUCTION.

During recent excavations on Kiboko Island in the Kavirondo Gulf of Lake Victoria, many specimens were obtained which bring to light what appear to be the first examples of pre-Pleistocene fossil deer from the African continent. The material is unfortunately fragmentary and incomplete, but it is at least sufficient to prove the existence of an entirely new form of deer in deposits presumed to be of Miocene age. This paper consists of a detailed description of the animal, together with a short discussion as to its origin. The diagnosis follows :—

CLIMACOCERAS, gen. nov.

Diagnosis.—A Cervine with non-deciduous straight antlers, bearing short irregular tines. Genotype. *Climacoceras africanus*, sp. n.

CLIMACOCERAS AFRICANUS, sp. n.

Diagnosis.—A primitive Cervine with permanent antlers; pedicle and 'burr' absent; beam straight, oval or cylindrical in section. Tines more or less perpendicular to the beam; irregular in number and disposition. Lower molars somewhat brachydont; enamel striated; protoconid and entoconid united; metaconid and hypoconid isolated.

Holotype.—No. KB. A.A.1 (of my collection) (fig. 1 c).

Dimensions of holotype.—Length 225 mm.; circumference at base 81 mm.

Paratype.—No. KB. A. 28 B (fig. 2 c).

Horizon.—Miocene.

Locality.—Kavirondo, Kenya Colony.

Description.

Antlers.

The collection includes a considerable number of antler fragments, many of which show at the base a portion of the frontal and parietal bones, extending to the orbit, and having the impression of cranial convolutions clearly marked on the inner surface. The antlers rise direct from the frontal bone to the first tine, and are not set on a pedicle or surrounded at the base by a 'rose' or 'burr', nor do they show the usual grooving of the beam.

The cross-section of the beam varies to some extent in each specimen, but in most cases there is a distinct lateral compression at the base, producing an irregular oval section. This may be maintained throughout the length of the beam or may merge into a round section. The circumference at the base varies from 70 to 92 mm. and the beam tapers gradually. The largest

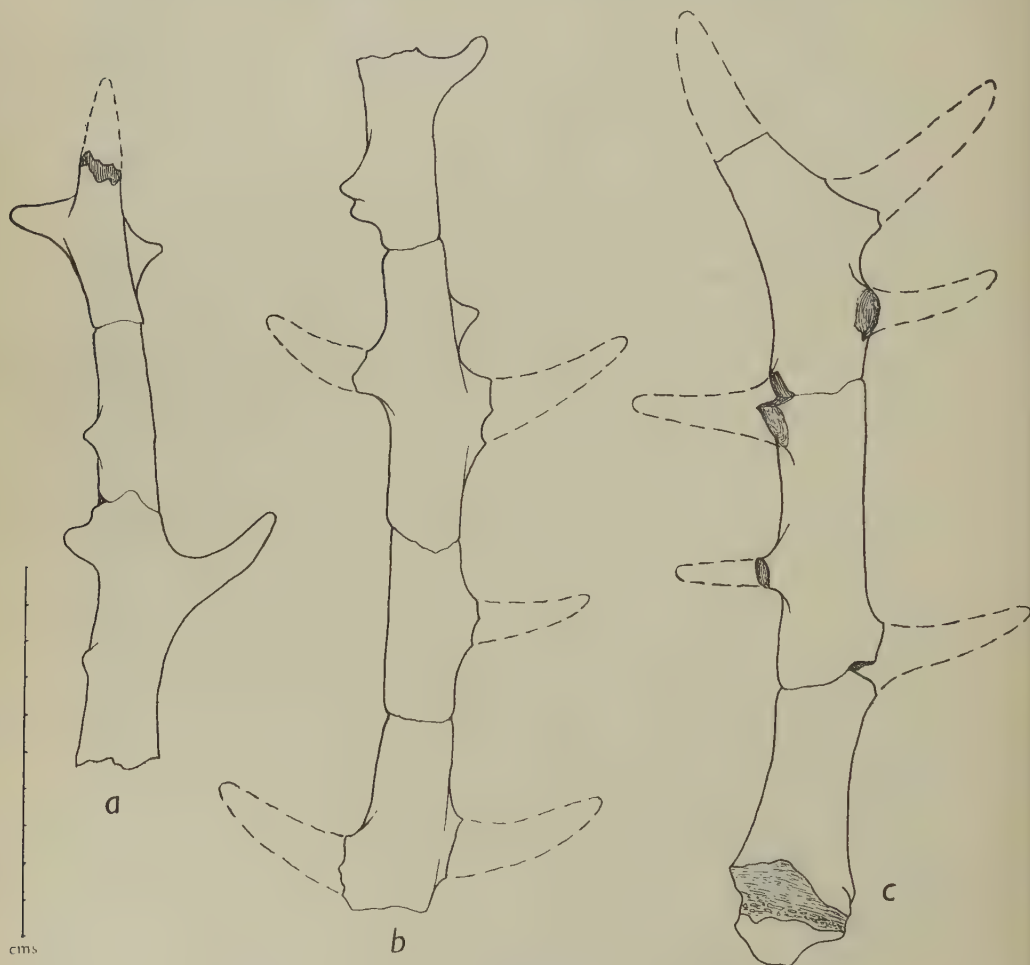


FIG. 1.—Three fragments of antlers showing the irregularity of tines. ($\frac{1}{3}$ natural size.)

fragment measures 235 mm. in length, the circumference being 70 mm. at the base and 54 mm. at the broken distal end. It is unlikely that the maximum length of any specimen was more than 300 mm. (about 12 inches).

The tines are very irregular both in size and position, but all are relatively short and project almost at right angles from the beam, thereby showing

another characteristic feature of this genus. The lowest tine, which may be compared to the normal brow-tine, is directed forwards, as in most of the known species of deer, while the remainder of the tines appear to have projected either forwards or backwards, but not laterally. The longest tine obtained measures 48 mm., whilst others are visible only as small lumps, but the arrangement on the beam is quite irregular and unlike most deer follows

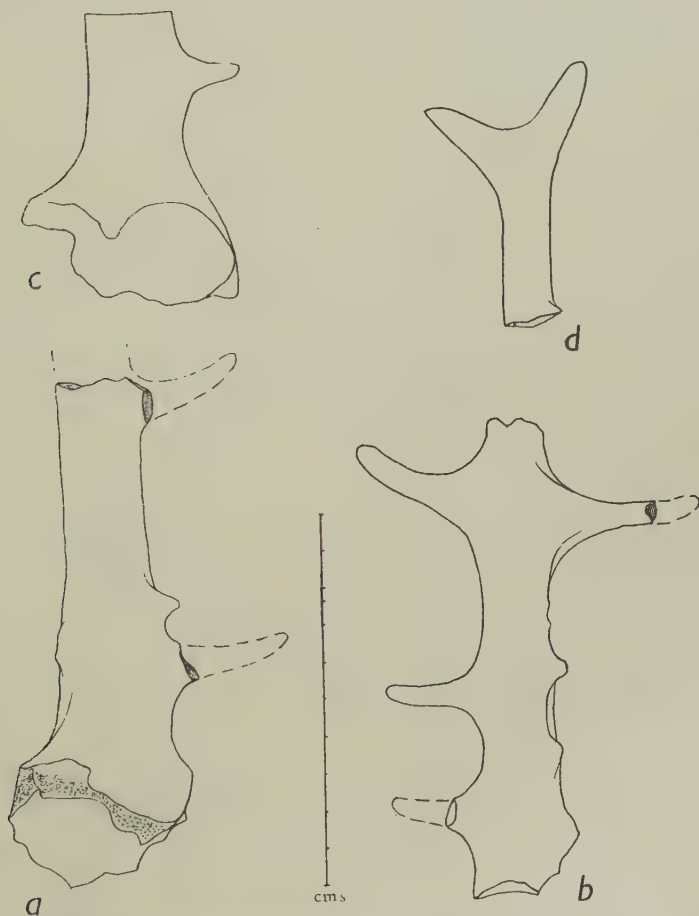


FIG. 2.—*a*, *c*. Antler fragments showing portions of frontal bone. *b*. Part of beam with irregular tines. *d*. Distal end of antler. ($\frac{1}{2}$ natural size.)

no constant pattern. This is shown clearly by two fragments of almost equal length and circumference, one of which bears nine tines, the other only five (fig. 1 *b*, *c*).

It seems that the two antlers diverged at a fairly wide angle (see fig. 4 *a*), but in lateral view probably appeared more vertical than is usual. They

retained a straight or nearly straight shaft throughout their length, apparently ending in a simple distal bifurcation (see fig. 2 *d*). None of the specimens

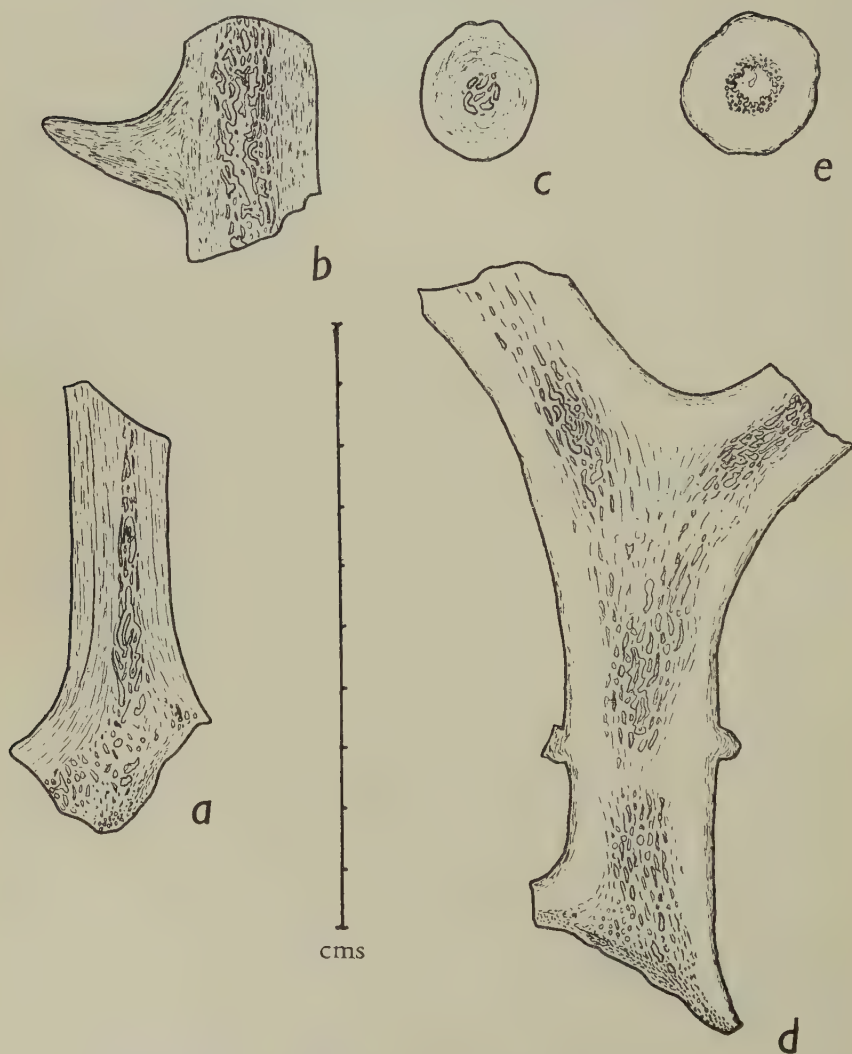


FIG. 3.—*a*. Longitudinal section of antler beam from frontal bone. *b*. Longitudinal section of beam and tine. *c*. Transverse section of beam. *d*. Longitudinal section through pedicle and base of antler of *Cervus elaphus*. *e*. Transverse section of beam (*C. elaphus*). ($\frac{4}{5}$ natural size.)

show any form approaching that of the Red Deer, with the regular brow, bez, and trez tines, nor is there any trace of palmation.

Internal structure.

Transverse sections of the beam show that it is composed of ordinary bone tissues, with an internal core of vesicular structure (fig. 3 c). The thickness of the outer solid portion varies in almost every specimen, but in no case do the vesicles come as near the surface as in the *Cavicorna*. Longitudinal sections show that the tines are formed entirely of the solid bone and have no trace of median vesicles (see fig. 3 b), while the core of cells in the beam arises directly from those of the frontal bone, and continues in an unbroken line apparently throughout the length of the shaft (fig. 3 a). A similar section through the antler of a Pleistocene deer shows that the vesicular structure itself divides and branches with the brow tine, and also that it is broken immediately below the 'burr', at the point of fracture, by a septum of solid bone (fig. 3 d).

Referring to the modern varieties of deer, Lydekker states that in the fully adult animal the pedicle has often lost all trace of internal vascular structure, but consists only of solid ivory-like bone, and that there can therefore be no internal source of nutrition to the antlers. The absence of the 'burr', and the continuity of the median vesicular structure in these new specimens, thus leads us to the conclusion that the antlers never lost their sources of nutrition, either external or internal, and therefore that they retained the skin covering or 'velvet' throughout the life of the animal, and were not shed annually.

Skull.

The fragments of skull attached to the antler shafts suggest that the animal corresponded closely in size to the European Roe Deer (*Capreolus caprea*), though the antlers were relatively longer, more divergent, and set wider apart. This is shown by a fragment in which the sagittal suture is present. Fig. 4 a shows a diagram of this fragment reconstructed symmetrically about the line of the suture. Fig. 4 b & c show similar diagrams of a Red Deer and a Roe Deer.

Teeth.

The few teeth obtained, which appear to be those of deer, were isolated, and not found in any close association with any of the other fragments. It seems, however, that since the fossiliferous horizon was only eight feet in depth, and since no other deer are yet known from the Miocene of Africa, we may safely assume that they belong to the same species. They are all somewhat brachydont, and show numerous fine vertical striations on the outer surface of the enamel. Loomis has pointed out that the antlered deer may be divided into two groups according to the pattern of the lower molars. He explains that by the formation of the lower molars from the original cone the more primitive of these two forms is that typified by *Rangifer*, in which the anterior crests and posterior crescents are united, leaving the posterior crests and anterior crescents isolated. In the later more advanced groups

this cross-over pattern is lost, to be replaced by a more symmetrical pattern, resulting from the fusion of the two crests on the lingual border and of the two crescents on the labial. In the present collection only three lower molars are in a sufficiently good state of preservation for the structure to be seen.

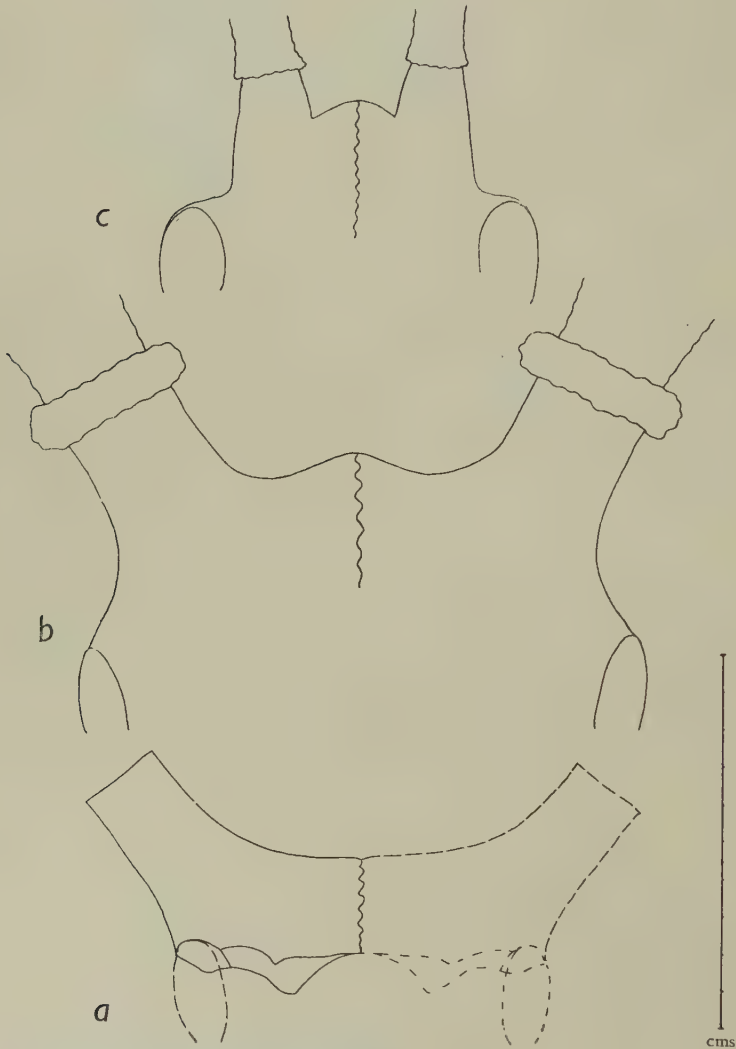


FIG. 4.—*a*. Front view of skull of *Climacoceras* compared with similar views of *Cervus elaphus* (*b*) and *Capreolus* (*c*). ($\frac{1}{3}$ natural size.)

These, however, show the cross-over pattern very distinctly (fig. 5), and if Loomis's theory be correct they may be considered to have affinities to the *Rangifer* group rather than to *Cervus* or *Cervulus*.

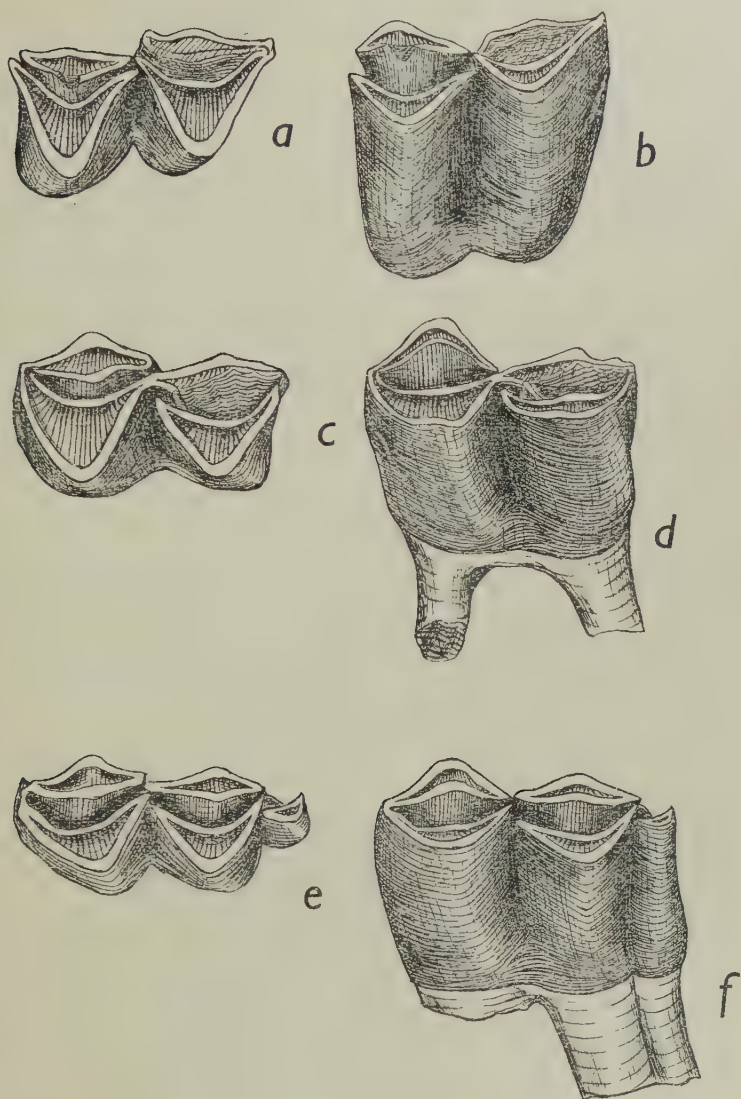


FIG. 5.—*a* & *b*. Second right lower molar. *c* & *d*. Second left lower molar.
e & *f*. Third left lower molar. (Twice natural size.)

The remainder of the material consists of a number of fragmentary limb-bones showing no distinctive characters.

CONCLUSIONS.

At the present day the only species of deer living in Africa is *Cervus elaphus barbarus*, a race of the European Red Deer, which is found in the Atlas Mountains and extends its range southwards as far as the Cameroons. Pleistocene deposits in North Africa have yielded the remains of *Cervus* (*Megaceroides*) *pachygenys*, distinguished by the extreme hypertrophy of the mandible, which is comparable to some of the Pleistocene deer of China. In the description of this species, however, no mention is made of any unusual antler fragments. With some of the more primitive forms such as *Palaeomeryx*, *Dromomeryx*, etc., the antlers were retained and not shed annually, but these were generally either unbranched or else bore a single tine, the whole antler being deeply grooved. The remaining Miocene varieties of antlered deer all show the more advanced arrangement of a pedicle and 'burr'.

In 1878 Brooke suggested the hypothesis that the ancestors of the modern deer had permanent antlers, but that these would become broken and thereby less efficient, and the animal would thus be more readily exterminated by those advanced forms which could renew their antlers annually. More recently Loomis (1928) has pointed out, in a paper on the phylogeny of the deer, that the structure of the antlers is such that it is most improbable that they originated more than once, but rather that all the antlered genera came from a common primitive stock. He suggests that the true deer originated in the early Miocene from the *Palaeomeryx* group, and spread in Pliocene times from Europe to Asia, Africa, and America.

If this theory be correct, the discovery of *Climacoceras* in the Miocene of Africa leads to the conclusion that some variety of the *Palaeomeryx* group migrated from Europe into Africa in early Miocene, or even Oligocene, times. In these animals the tendency towards multiple division of the antlers was already present, whilst the system of annual shedding and renewal had not yet developed. If this variety became isolated in the forests of Central Africa, the lack of competition with more advanced forms of deer would enable it to persist. Thus, although the need to shed and renew the antlers might not arise, the tendency to increase the number of tines might well continue to develop.

The present paper deals almost exclusively with antler characters, for want of more complete material. Some authorities consider this to be an unsatisfactory basis for the separation of new genera, but the unique type of antlers shown by *Climacoceras* seems in this case to be sufficient justification. It is hoped that further collecting in the same area may yield more complete evidence of the osteological and dental characters of this form.

IN a paper read before the Linnean Society in April 1934, Mr. Warren R. Dawson discussed the occurrence in certain Ancient Egyptian tombs and monuments of wall-paintings and engravings which he says clearly represent a form of deer. These pictures range from Predynastic times to the Eighteenth Dynasty. He pointed out that, at the time of writing, both recent and fossil deer were entirely lacking in the Ethiopian Region of Zoological Distribution, and that there was therefore no indication that deer had ever been a part of the Nile Valley fauna. For this reason he took the view that the unusual type of antlers depicted represent a conventionalised form of some known species, probably due to cultural contact with races familiar with Asiatic varieties of deer. He also suggested the possibility that captive animals were on rare occasions brought into Egypt by travellers, but he pointed out that in any case 'it may be taken for granted that the deer of Egypt, whether natural or introduced, were derived from species whose habitats are nearest to that country'.

On the other hand, it is interesting to find that L'Abbé H. Breuil, in a paper published in the same year (1934), records a painting of a deer with somewhat similar antlers in a cave near Dire-Dawa in Abyssinia. Moreover, he reproduces a fresco from the church of Zara Brouk (Addiet), which again represents a deer, and he states that M. Griaule, who discovered this painting, was informed by the local natives that the animal depicted still exists in the region of Lake Tana, the source of the Blue Nile.

The discovery of *Climacoceras* near the source of the White Nile seems to suggest a possible new line of argument, particularly as the antlers of this new genus bear a striking resemblance to all these pictorial representations, both from Egypt and from Abyssinia.

The exact geological horizon of these remains cannot be determined, but, to judge by the other mammalian fossils, the deposit would appear to be of Miocene age. There is, however, no reason to suppose that at the time of deposition the genus *Climacoceras* was on the verge of extinction. The varying altitudes of this part of Africa result in a wide range of climatic conditions, and many groups of mammals have therefore been afforded a habitat suitable to their own requirements, which has enabled them to persist in this area after they had become extinct in other parts of the world. It therefore seems possible that this group of deer, or descendants from it, did in fact persist into more recent times. If this be so, the final extinction of the group may have been fairly recent, or indeed may not yet have taken place. In either case it is reasonable to suppose that the animals would have persisted longest in the most suitable environment.

The occurrence of Miocene fossil forests in North Kenya and in Somaliland at similar altitudes suggests that the Nyanza region may also have been forested in Miocene times. To some extent this is borne out by the associated remains of *Proconsul* and *Bunolophodont* Mastodons.

At the present time there are, in the Ituri region of the Belgian Congo and the highlands of Abyssinia, forest areas under varying climatic conditions. Thus, if we postulate that descendants of the genus *Climacoceras* could have survived, one might reasonably expect to find them living in one of these localities. The evidence of the Abyssinian paintings and the native story would seem to support this hypothesis, which may also supply a possible explanation of the Ancient Egyptian drawings.

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Studies in the Arabian Orthoptera.—I. Descriptions of new genera, species, and subspecies. By B. P. UVAROV, D.Sc., British Museum (Natural History). (Communicated by Dr. HUGH SCOTT, M.A., F.L.S.)

(PLATES 10 & 11 and 5 Text-figures*)

[Read 7 May 1936]

THE Arabian peninsula remains one of the least explored areas with regard to its Orthopterous fauna, while its unique geographical position makes its exploration of the greatest value for the elucidation of a number of problems bearing on the origin and the distribution of life in the southern borderlands of the Palaearctic region. Difficulties of travelling and collecting in Arabia are such that the time for a thorough study of its fauna will not be ripe for many years, but I was encouraged to make at least an attempt at a preliminary survey by the willing assistance offered by the well known traveller in Arabia Mr. H. St. J. B. Philby, who for the last few years was supplying the British Museum with abundant insect material in which Orthoptera always play a prominent part. Mr. Philby's collections, made in various regions of Arabia, some of them never visited by European travellers, would permit one already to form a general idea of the fauna and of its distribution over the country. Further important data on the subject have been obtained by me from the study of the collections made by Messrs. C. Rathjens and H. v. Wissmann in Yemen and Hadramaut and placed at my disposal by Dr. E. Titschak of the Hamburg Museum. In addition, Mrs. M. C. Rant supplied me with most interesting Orthoptera collected during several months near Aden and in the Lahej protectorate, while Mrs. H. R. P. Dickson and Miss Zahra Dickson are regularly sending me Orthoptera from the little-known Kuwait territory. More recently, Mr. R. C. Maxwell Darling, while exploring the Arabian coasts of the Red Sea in connection with investigations on the locust problem, commenced collecting Orthoptera, and some of his materials have already reached me. Several smaller collections from Arabia were also in my hands, so that it would be possible already now to prepare a list of the fauna. It appears wiser, however, not to hasten with this work, particularly because some of the collectors mentioned above hope to continue their activities in future. On the other hand, it should be of interest to other orthopterists and to the existing and prospective collectors to see published the descriptions of at least the outstanding novelties found in the collections already studied. I have decided, therefore, while postponing the

* The cost of reproducing these illustrations has been borne by the Westwood Fund.

publication of a comprehensive work on the Arabian fauna, to publish from time to time descriptions of new genera, species and subspecies, as well as notes on the less known and interesting ones. The present paper is the first of this series, and I am greatly pleased to be able to give the persons who are assisting me by collecting specimens this substantial proof of the scientific value of their work. Knowing from my own experience how tiring can be a hunt for elusive grasshoppers under blazing sun, I am doubly grateful for their unselfish efforts.

Further assistance on the part of collectors, especially those who happen to be resident in Arabia, would be greatly appreciated. Full instructions as to the best methods of collecting and preserving Orthoptera will be supplied by me on application.

BLATTIDAE.

HETEROGAMODES CHOPARDI, sp. n.

♂. In the Chopard's key ('Eos', v, 1929, p. 285) comes near *H. bifeveolata* I. Bol., but is larger, differently coloured and armed with 11 upper spines on hind tibia.

Eyes more broadly separated than the ocelli. Frons between ocelli distinctly carinated, below the carina deeply excavated.

Pronotum strongly transverse; anterior margin prominent above the head; lateral margins broadly rounded, truncate; posterior margin broadly rounded.

All femora unarmed apically. Tarsi without arolia. Anterior tibia with 8 apical spines and 1 spine above; intermediate tibia with 6 apical spines and 7 upper ones; posterior tibia with 6 apical, 11 upper and 4 lower spines.

Elytra elongate, narrow.

Coloration very light buff; pronotum with brownish pattern; elytra brownish, with very indefinite darker spots; their marginal field and the circular anal furrow whitish.

Total length 22; length of body 15; elytra 19; pronotum 4; width of pronotum 6.5 mm.

Muwaih, 15. xii. 34, 1 ♂ (*type*); Arma, 3. xii. 31, 1 ♂ (paratype) (*H. St. J. B. Philby*).

It gives me much pleasure to dedicate this species to the author of the recent monograph of Polyphaginae, my friend Dr. Lucien Chopard.

HETEROGAMODES MARMORATA, sp. n.

♂. Allied to *H. similima* Chopard (*l. c.*), but larger and differing in darker coloration and the armature of hind tibia.

Eyes more narrowly separated than ocelli. Frons between ocelli obtusely carinated,

Pronotum with the anterior margin well convex, broadly prominent in the middle; posterior margin scarcely convex.

All femora unarmed apically. Tarsi with the arolia scarcely perceptible, rudimentary. Anterior tibia with 8 apical and 1 upper spine; middle tibia with 8 apical, 7 upper and 1 lower spine; posterior tibia with 7 apical, 4 lower and 10 upper spines, the latter being more or less evenly distributed.

General coloration greyish brown, with pale yellowish marbled pattern on the elytra. Head blackish above; frons blackish brown. First antennal joint brown. Abdomen light yellow underneath.

Total length 28; body 18; elytra 23; pronotum 5; width of pronotum 8.5 mm.

Taif, 4,000–5,000 ft., 3. vii.–5. ix. 1934, 9 ♂♂ (*H. St. J. B. Philby*).

MANTIDAE.

ATTALIA *, gen. nov.

Similar to *Galinthias*, but differing from it by a protuberance on the vertex, by less acute eyes, by the shape of pronotum, and by the bilobate posterior tibiae.

♂. Antennae moniliform, with very short, scarcely perceptible hairs.

Head with the vertex deeply excised and provided with a median protuberance which is constricted at the base and incompletely divided apically. Facial scutellum concave, with the margins well raised. Eyes kidney-shaped, narrowly rounded but not acute apically.

Pronotum with a strong, suddenly terminating expansion in the anterior part of the metazona.

Armature of front legs as in *Galinthias*. Middle and hind femora with narrow lobes as in *Galinthias*. Middle and hind tibiae each with two narrow lobes, those of the hind tibiae better developed.

ATTALIA PHILBYI, sp. n. (Fig. 1.)

♂. Small, brownish green (probably light green in life).

Facial scutellum subpentagonal, rounded above, about as high as broad. Protuberance of the vertex as long as the eyes. Maximum width of the pronotum equal to the width of head between eyes; metazona of the pronotum behind the expansion saddle-shaped, with two small tubercles at the posterior margin.

Length of body 18; pronotum 5.5; elytra 14 mm.

S. Hedjaz, Ashaira, 12. viii. 1931, 1 ♂ (*H. St. J. B. Philby*).

This curious little Mantid represents a mixture of characters of two genera, *Galinthias* and *Anasigerpes*, since the shape of its head, with its projecting eyes, is like that in *Galinthias*, while the protuberance of the vertex and the

* *Attali* was a predatory Arabian tribe mentioned by Pliny.

bilobate posterior tibiae are peculiar to *Anasigerpes*. The shape of the pronotum is different from that in both genera.

Galinthias, *Anasigerpes* and allied genera belong to the fauna of Tropical Africa, which makes a discovery of a related genus in Arabia of considerable zoogeographical interest.

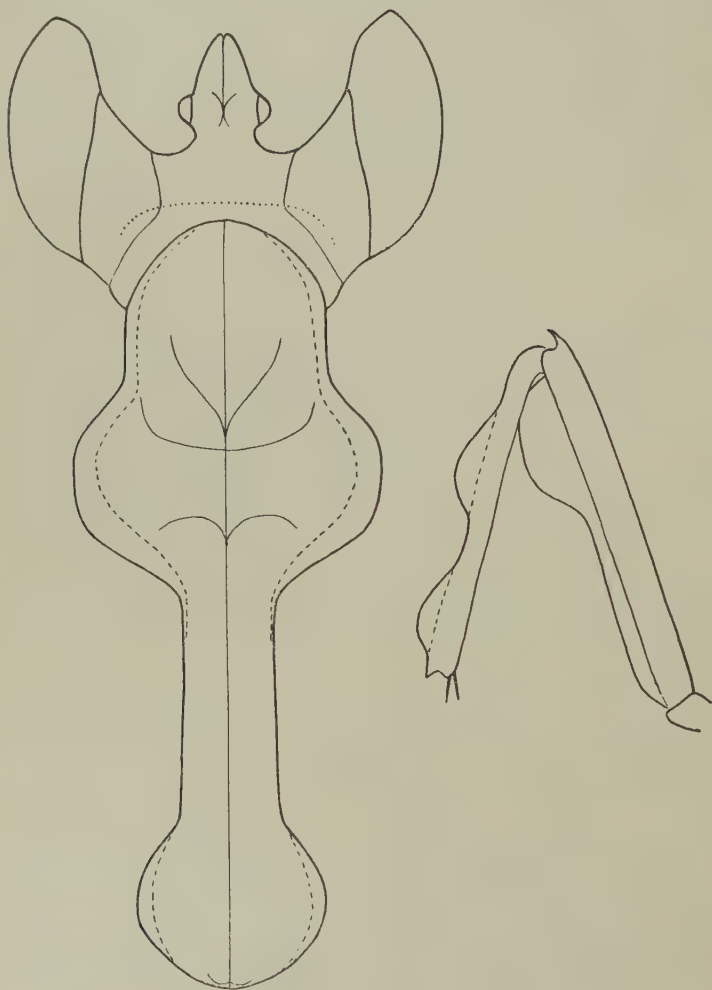


FIG. 1.—*Attalia philbyi*, sp. n.

TETTIGONIIDAE.

EURYCORYPHA ARABICA, sp. n. (Fig. 2, A.)

♂. Under medium size, uniformly green; antennae green basally, gradually becoming brown towards the middle.

Pronotum somewhat rugulose ; anterior margin roundly emarginate, somewhat wavy ; posterior margin rounded.

Anterior tibia compressed laterally, flat above. Posterior femur with a few spinules on the inner lower carina.

Last tergite fused with the supra-anal plate into a large bicarinate appendage ; the apex of the appendage bears above a triangular median folded lobe, which in the case of the typical subspecies is large and as long as half of the appendage. Cercus shorter than the appendage, compressed laterally, particularly near the apex, where it is excavated on the inside ; upper edge in profile concave and then broadly convex ; a strong spine beyond the middle of the inner side directed obliquely downwards (fig. 2, R.) Subgenital plate with the apex narrow, emarginate.

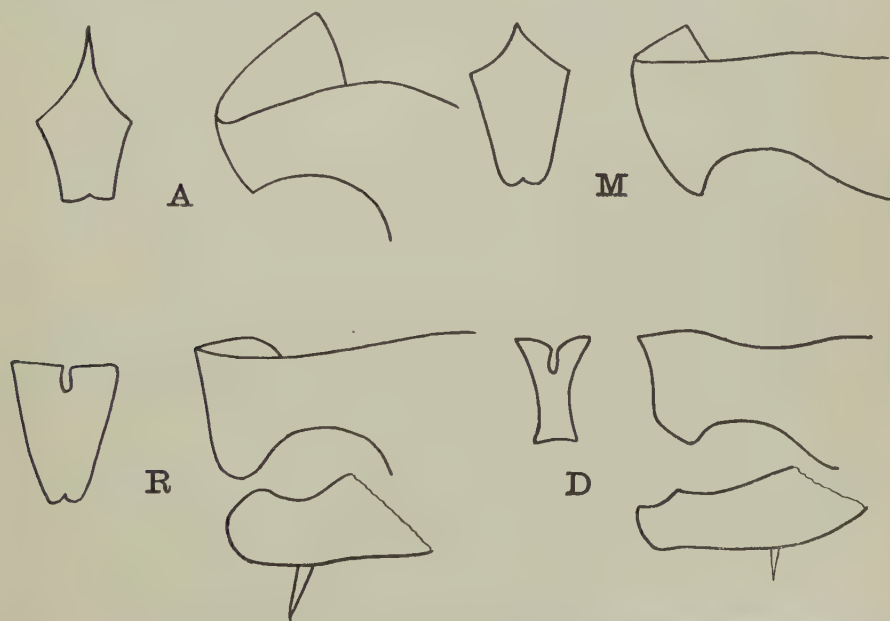


FIG. 2.—A, *Eurycorypha arabica arabica*, sp. n., supra-anal appendage viewed from behind and from the side ; M, *E. a. media*, subsp. n., ditto ; R, *E. a. reducta*, subsp. n., ditto and side view of the cercus ; D, *E. darlingi*, sp. n., ditto.

Length of body 19 ; pronotum 4.5 ; elytra 28 ; hind femur 14 mm.

S. Hedjaz : Taif, 3. ix. 1934, 1 ♂ ; 6. ix. 1934, 1 ♂ (*type*) ; 10. viii. 1931, 1 ♂ (*H. St. J. B. Philby*).

EURYCORYPHA ARABICA MEDIA, subsp. n. (Fig. 2, M.)

♂. Differs from the typical *E. arabica arabica* in the less developed folded lobe of the supra-anal appendage, this lobe occupying not more than a third of the length of the appendage. The difference in shape of the apex of the appendage is very striking when seen directly from behind.

S.W. Arabia : El Kubar, 3 ♂♂ (*G. W. Bury*).

EURYCORYPHA ARABICA REDUCTA, subsp. n. (Fig. 2, R.)

♂. Characterized by still greater reduction of the folded lobe of the supra-anal appendage. Seen in profile the lobe is quite small, hardly projecting upwards. The difference in the shape of the apex is obvious from the figures.

Hadramaut: Wadi Humum (or Himim) near Makalla, 9-10. v. 1931, 1 ♂ (*H. v. Wissmann*).

Type in the Hamburg Museum.

It is a very interesting fact that a species of the tropical African genus *Eurycorypha* should be found in Arabia. It is still more interesting that the specimens from three localities in Arabia should be very distinct in certain morphological details, while those from each one of these localities are absolutely identical. This can only be explained as a result of an isolation of small colonies of the species in a few favourable localities, where distinct subspecies have been produced as a result.

EURYCORYPHA DARLINGI, sp. n. (Fig. 2, D.)

♂. Smaller than *E. arabica*, with more narrow elytra, and differing in the male genitalia, particularly in the structure of cercus.

Pronotum scarcely rugulose; anterior margin distinctly roundly emarginate; posterior margin circular.

Posterior femur with a few spinules on both the lower carinae.

The appendage formed by the last tergite and supra-anal plate is excavate above, divided apically into two lancet-shaped lobes; it has a median carinula in its apical part, too low to be visible in profile; the profile of the appendage and the view of its apical part from behind as figured. Cercus practically as long as the appendage, very different in its outline from that in *E. arabica*, being excised near the apex above; its inner spine weak and placed in the basal half. Subgenital plate with emarginate apical margin.

Length of body 18; pronotum 4; elytra 25; hind femur 13-5 mm.

Aden Protectorate: Makhnang, x. 1935, 5 ♂♂ (including the *type*) (*R. C. Maxwell Darling*).

ACRIDIDAE.

ACRIDA CURTA, sp. n.

Similar to the Mediterranean *A. turrita* L., but differs from it in being smaller and more robustly built, in the fastigium of vertex not widened but somewhat narrowed forward, and in slightly infumate wings.

♂. Antennae somewhat longer than head and pronotum together; joints 3-6 expanded; fourth joint square.

Head strongly ascending, only a little longer than pronotum. Vertex three-fifths of the length of an eye, about half again as long as wide at the base; gradually narrowed towards parabolic apex; surface with a deep longitudinal

concavity, and with a very weak median carinula; lateral margins rounded, without the elongated flat surfaces corresponding to the foveolae.

Pronotum finely granulate, obtusely tectiform. Median carina as in *A. turrita*, intersected by the transverse sulcus exactly in the middle. Lateral carinae parallel and slightly concave in the prozona; somewhat divergent and convex in the metazona. Posterior angle about 90°, slightly attenuated, with the sides weakly concave. Posterior lower angle of lateral lobes rounded, scarcely projecting backwards.

Mesosternal lobes about as broad as long, with the inner angle obtuse, rounded. Mesosternal interspace about two-thirds of the width of a lobe and about half again as long as wide.

Elytra scarcely projecting beyond the hind knees.

Tarsal arolia narrow, a little longer than half of a claw.

Colour uniformly green; antennae and legs yellowish.

♀. Antennae shorter than head and pronotum together. Head as long as pronotum. Colour usually green, but in some females buff, with brown and white pattern as in *A. turrita*.

Length of body, ♂ 30, ♀ 46; head, ♂ 5.5, ♀ 9; pronotum, ♂ 5, ♀ 8.5; elytra, ♂ 25, ♀ 39; hind femur, ♂ 19, ♀ 28 mm.

Yemen: Sanaa, vii.-ix. 1931, 17 ♂♂ (including the *type*), 19 ♀♀ (*Dr. C. Rathjens*). Type and paratypes in the Hamburg Museum; three pairs of paratypes in the British Museum.

The new species is somewhat similar in its appearance to the Indian *A. exaltata* I. Bolivar, which has, however, a longer and parallel-sided fastigium of vertex, less expanded antennae, longer head, and more selliform pronotum.

PLATYPTERNA OBSOLETA, sp. n. (Fig. 3.)

Very similar to the Sudanese *P. johnstoni* Salfi, 1931, but well distinct from it and from all known species by the practically obsolete foveolae of vertex.

♀. Antennae short, not reaching back to the typical sulcus of the pronotum, feebly dilated in less than the basal third of their length. Third joint trapezoidal, a little longer than broad, subdivided; fourth strongly transverse, short; fifth a little longer than fourth, transverse; sixth narrower than fifth, a little broader than long; seventh narrower than sixth, about half again as long as wide; eighth still narrower, longer than seventh, subdivided; ninth and tenth slightly flattened; the rest cylindrical, about twice as long as wide.

Head short and thick. Vertex very short, broadly rounded, with distinct median carinula. Foveola represented by a small irregular depression close to the ocellum and one or two punctures in front of it. Frontal ridge seen in profile very slightly convex; its surface convex above the median ocellum, shallowly sulcate below it, with thick carinae.

Pronotum with the lateral carinae thick, straight, a little divergent backwards. Surface of the disc and lateral lobes punctured. Lower margin of lateral lobe weakly sinuate.

Elytra extending beyond hind knees by less than a fourth of their length.

Posterior femora very thick, not constricted in front of the knee.

General coloration stramineous; top of the head and pronotal disc white; a narrow brown stripe runs from the eyes along the upper margin of pronotal lobe and the radial veins. Inner knee lobe without a dark spot. Hind tibia dirty blue.

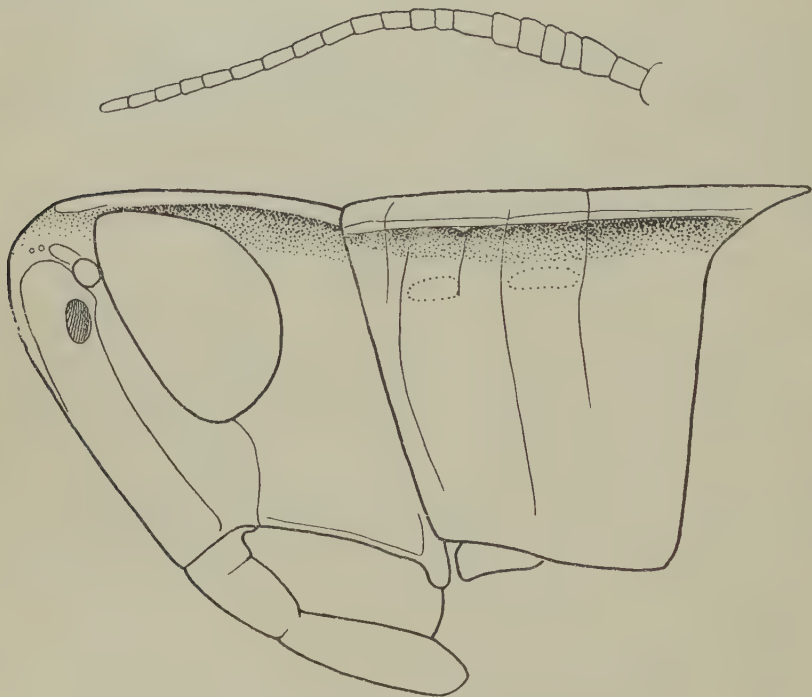


FIG. 3.—*Platypsyterna obsoleta*, sp. n.

Length of body, ♂ 19, ♀ 27; pronotum, ♂ 3.5, ♀ 5; elytra, ♂ 15, ♀ 22; hind femur, ♂ 9, ♀ 14 mm.

Taif, 6. ix. 1934, 1 ♀; 10. ix. 1934, 1 ♀ (*type*); Hafair, 11. viii. 1934, 1 ♂ (*H. St. J. Philby*).

XEROPHILAEoba, gen. nov.

Differs from *Phlaeoba* St. by the slender habitus, non-rugose pronotum, and by the metasternal lobes being contiguous even in the female sex.

Antennae long, ensiform. Face strongly oblique. Frontal ridge viewed in profile strongly projecting forward between antennae, sulcate throughout. Fastigium of vertex longer than broad, rounded in front; its surface behind the bow-shaped sulcus is convex; margins acute; no foveolae. Eyes elongate-oval, oblique. Pronotum compressed laterally, flat above, with parallel carinae;

typical sulcus well behind the middle; lateral lobes longer than high, with the lower margin ascending anteriorly. Mesosternal lobes about as long as broad, with the interspace narrower than a lobe; metasternal lobes contiguous in both sexes. Elytra narrow, rounded apically; scapular area in the male not expanded; discoidal and interulnar areas with irregular false veins. Posterior femora slender; knee lobes of normal length, subacute.

Genotype: *Cymochtha deserticola* Krauss, 1902.

The type of this new genus is not a *Cymochtha*, since in that genus the frontal ridge is normal, not projecting between antennae. In its general habitus the insect reminds one of a *Wilwerthia*, but is less slender, and the elytra are not pointed at the apex.

The genus includes two known species, as follows:—

XEROPHILAEOPA DESERTICOLA (Krauss).

1902. *Cymochtha deserticola* Krauss, Anz. Akad. Wiss. Wien, 1902, no. vii, p. 2.

1907. *Cymochtha deserticola* Krauss, Denkschr. Akad. Wiss. Wien, mat.-nat. Kl. vol. lxxi, p. 6, pl. i, figs. 4, 4 A, 4 B.

1908. *Orthochtha prionocera* I. Bolivar, Bull. Soc. Ent. Fr. 1908, p. 243 (*syn. nov.*).

The types of *C. deserticola* described from Aden and of *O. prionocera* known from Lahej have been compared and found conspecific.

XEROPHILAEOPA SCHULTHESSI (Kirby).

1898. *Phlaeoba antennata* Schulthess-Schindler, Ann. Mus. Civ. Genova, ser. 2, vol. xix, p. 185, pl. ii, fig. 8 (*nec* Brunner von Wattenwyl!).

1910. *Rodunia schulthessi* Kirby, Syn. Cat. Orth. iii, p. 140.

1910. *Orthochtha schulthessi* Kirby, *l. c.* p. 580.

Owing to the courtesy of Dr. F. Capra I have studied the two cotypes of *P. antennata* Schulth., a male and a female. They proved to belong to distinct species and even genera. The male is a *Duronia*, and is left here out of consideration, while the female labelled "Deserto di Banas vii, 1893" and here selected as the type is a *Xerophlaeoba*. It is closely allied to *X. deserticola*, but differs from it in the female sex as follows:—

- | | |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|
| 1 (2). Antennae longer and more dilated basally. Fastigium of vertex longer; its apex parabolic; the portion in front of the sulcus is almost as long as the convex part behind the sulcus. Frontal ridge in profile distinctly projecting forward between antennae. Pronotum relatively longer and narrower.—Lahej | <i>deserticola</i> . |
| 2 (1). Antennae shorter and less dilated basally. Fastigium of vertex shorter; its apex circular; the anterior portion much shorter than the posterior. Frontal ridge in profile practically straight, scarcely projecting between antennae. Pronotum relatively shorter and broader.—Italian Somaliland | <i>schulthessi</i> . |

I possess a pair of specimens from Aden which may prove to belong to a third species of *Xerophlaeoba*, but refrain from describing them in the hope of obtaining more material.

BODENHEIMERELLA ARABICA, sp. n. (Plate 11, fig. 5.)

Differs from the only known species of the genus (*B. jordanica* Uvarov, 1933) by fully developed elytra with different venation, as well as by the larger size.

♂. Antennae long, reaching back nearly to the base of hind femora.

Face strongly oblique. Frontal ridge in profile straight except near the fastigium, where it becomes convex and forms an obtuse angle with the vertex; surface sulcate throughout; margins well raised, straight, almost parallel. Fastigium of vertex feebly sloping, pentagonal, a little longer than wide; surface concave; margins well raised, the lateral ones somewhat converging behind.

Pronotum slightly constricted in the middle; metazona a little shorter than prozona, rounded behind. Median carina low in prozona, more raised in metazona. Lateral carinae slightly convergent to the first sulcus, obsolete between sulci, very distinct and somewhat divergent in metazona. All transverse sulci distinct. Elytra reaching the hind knees; venation as figured (Pl. 11, fig. 5).

General coloration greyish buff variegated with brown. Antennae light brown. Pronotum with pale cruciate pattern; lateral carinae in metazona accompanied by rather wide triangular spots (as in *Dociostaurus kraussi* Ingen.); lateral lobes blackish in the middle, with a light callous median spot and a few blackish spots on the anterior margin. Pleurae with black marks. Elytra with some fairly large brown spots; the apex more infumate. Wings hyaline. Legs with brown fasciae. Hind femur with the usual brown fasciae above and black dots on the carinae. Hind tibia greyish.

Length of body, ♂ 11, ♀ 16.5; pronotum, ♂ 3, ♀ 3.5; elytra, ♂ 10, ♀ 13; hind femur, ♂ 8, ♀ 10 mm.

Jumum, 30. xi. 1928, 1 ♂; Mecca, 3. xi. 1934, 1 ♂; Hadda, 17. iv. 1934, 1 ♀; 18. vii. 1934, 1 ♂ (*type*), 1 ♀ (*H. St. J. B. Philby*).

The genotype of *Bodenheimerella* is a species with abbreviated elytra, the venation of which is, in consequence, somewhat aberrant. The new species shows the great affinity of *Bodenheimerella* to the recently described *Kazakia* Bey-Bienko, 1933, which, however, has almost triangular foveolae of vertex. The genus *Eremippus*, to which *Bodenheimerella* is similar in appearance, differs by the presence of an intercalate vein in the discoidal field; this vein is absent in both *Kazakia* and *Bodenheimerella*.

STENOHIPPIUS ARABICUS, sp. n.

Closely allied to *S. xanthus* (Karny, 1907), known from the Sudan and Northern Nigeria, but differing from it in the fastigium of vertex more prominent forward, frontal ridge sulcate and more oblique in profile; foveolae of vertex very narrowly separated in front; metazona of pronotum longer than prozona.

♂. Antennae much longer than head and pronotum together.

Face distinctly oblique in profile. Frontal ridge shallowly sulcate below the ocellum, strongly constricted, almost linear, between the foveolae. Fastigium of vertex narrow, deeply concave, sloping, with very acute apex. Foveolae of vertex well margined below, very narrowly separated in front.

Pronotum slightly saddle-shaped. Median carina low, cut by the typical sulcus behind the middle. Lateral carinae strongly inflexed, but not angulate, intersected by the first and the third sulcus, obliterated between the sulci. Metazona shorter than prozona, as long as its maximum width, obtusely angulate behind.

Elytra extending beyond the hind knees by one-fourth of their length.

General coloration brownish buff, speckled with reddish brown and with light buff pattern. Pronotum light buff along the middle; lateral carinae yellowish, enclosed in velvety brown fasciae; lateral lobes with an ivory-white spot about the middle. Elytra with irregular brownish spots. Hind femur with the typical brown spots above. Hind tibia light bluish grey.

Length of body, ♂ 12, ♀ 16; pronotum, ♂ 2, ♀ 3; hind femur, ♂ 7, ♀ 8; elytra, ♂ 11, ♀ 15 mm.

Hedjaz: Mecca, 8. iii., 1 ♀; 18. iii., 1 ♀; 16. v., 1 ♂; 21. v., 1 ♂; 9. vii., 1 ♀; 2. x., 1 ♂; 6. x., 2 ♂♂, 3 ♀♀; 7. x., 1 ♂, 1 ♀; 9. x., 1 ♀; 20. x. 1931, 1 ♂ (*type*); Jidda, 28. iii. 1930, 1 ♀; Medina, 17. vi. 1931, 1 ♂, 1 ♀; Hafair, 10. viii. 1934, 2 ♂♂, 2 ♀♀ (*H. St. J. Philby*).

In some specimens there is a sharply defined broad pale stripe on the pronotum, and one female is coloured as the form *castaneopicta* known in many species of *Dociostaurus*.

MESOPSIS ALIENUS, sp. n.

Allied to *M. abbreviatus* (P. B.) of West-African savannas, but differing from it in broader and shorter antennae, shorter head and male subgenital plate, relatively longer elytra, and non-infumate wings.

♂. Antennae about half again as long as head and pronotum together, strongly expanded in more than half of their length.

Fastigium of vertex of the same type as in *M. abbreviatus*, i.e. without reflexed margins, gradually narrowed towards parabolic apex; carinated along the middle; its length less than twice the length of an eye.

Pronotum somewhat saddle-shaped above; its surface rugulose. Median carina weak. Posterior margin of the disc rounded, more prominent than the anterior.

Elytra reaching a little beyond the fifth tergite, relatively narrow, with all fields less expanded than in *M. abbreviatus*.

Posterior femur relatively short.

Cerci straight, scarcely tapering. Subgenital plate straight, a little longer than head.

Colour uniformly light stramineous, with the head, pronotum and pleurae somewhat reddish. Subgenital plate scarcely darker than the rest of the body.

Length of body (with the subgenital plate) 50; antennae 16; head 8.5; pronotum 5; elytra 24; hind femur 13.5; subgenital plate 9.5 mm.

Hedjaz: Mecca, 8. iv. 1932, 1 ♂ (*H. St. J. Philby*).

The genus *Mesopsis* is one of the most typical members of the African savanna fauna, and the discovery of a species in Arabia is therefore of interest. It is worthy of notice that the Arabian species is allied to a West African one which differs considerably in the structure of the vertex from others distributed over most of Africa.

OEDALEUS OBTUSANGULUS, sp. n. (Plate 10, figs. 2, 2 a.)

A small but robustly built species, with obtusely angulate pronotum and relatively short elytra.

♀. Antennae a little shorter than head and pronotum together.

Frontal ridge in profile vertical, straight, forming an obtuse rounded angle with the fastigium of vertex; its surface concave from the base of antennae down to more than half-way between ocellum and clypeus. Fastigium of vertex distinctly sloping, pear-shaped, a little longer than at the base broad; surface distinctly concave, with well-raised margins; median carinula represented only by an elongated tubercle at the junction of the concave fastigium with the convex vertex proper. Foveolae of vertex feebly concave, triangular, reaching about to the middle of fastigium.

Pronotum short, little constricted in prozona, which is a little longer than metazona. Front margin obtusely angulate, the sides being concave. Hind margin forming an angle about 120° , with the sides straight. Median carina tectiform, well raised, practically straight in profile. First and third sulcus deep. Surface of metazona rugulose, particularly on the lateral lobes.

Elytra extending a little beyond hind knees, narrowed towards apex. Discoidal field with the false vein slightly approaching the radial towards the apex.

General coloration dull greyish buff. Sides of the head with grey pattern. Pronotum with the X-shaped pattern fairly broad, interrupted in the middle. Elytra in the basal two-thirds brownish, with two incomplete light fasciae at the anterior margin. Wing hyaline, with a narrow, interrupted fascia. Hind tibia dirty yellowish.

Length of body 25; pronotum 5.5; hind femur 12; elytra 20 mm.

Buraiman, 17. ii. 1929, 1 ♀ (*H. St. J. B. Philby*).

GASTRIMARGUS VOLKENSI ARABICUS, subsp. n.

♂. Differs from the typical Kilimanjaro form by smaller size, relatively shorter pronotum and practically obsolete pattern of elytra.

Length of body, ♂ 22, ♀ 43; pronotum, ♂ 6.5, ♀ 11.5; elytra, ♂ 26, ♀ 43; hind femur, ♂ 16, ♀ 29 mm.

Yemen: Sanaa, viii. 1931, 1 ♂ (*C. Rathjens*; type in the Hamburg Museum).

Aden Protectorate: Dhala, x. 1935, 1 ♀ (*R. C. Maxwell Darling*).

In the typical form the pronotum is half the length of hind femur, while in the Arabian subspecies it is only two-fifths of it, the posterior angle being less produced and broader.

PYCNODICTYA GRACILIS, sp. n. (Plate 10, figs. 1, 1 α .)

A relatively slender species, with well prominent vertex and crested pronotum, with the hind wings either light cinnabar-red or yellow.

♂ (*type*). Antennae longer than head and pronotum together.

Frontal ridge in profile forming an obtuse rounded angle with the vertex ; its surface rugulose, concave at the ocellum ; margins little sinuate. Fastigium of vertex sloping, longer than broad ; surface concave, with deep pits and callous tubercles ; margins strongly raised, callous ; median carinula present on the vertex, but abruptly ending at the base of fastigium ; foveolae of vertex subtriangular, short.

Pronotum compressed laterally and constricted in prozona, very coarsely rugose. Prozona distinctly shorter than metazona, which is strongly acutangular, with the sides weakly concave. Median carina well raised, but thick and rugose on its sides ; seen in profile it is almost straight, depressed at the apex. Lateral lobes nearly twice as high as long ; lower margin strongly sinuate.

Elytra extending beyond hind knees, transparent in the apical third.

General coloration pale ochraceous, with indefinite grey and brown markings. Elytra spotted with grey. Wings light cinnabar-red in the basal part ; dark fascia narrow, touching posterior margin, and with a short radius ; apical part hyaline, with a few small brownish spots near the apex.

Hind femur internally black, with a preapical light fascia. Hind tibia honey-yellow.

♂ (*paratype*). Wings yellow ; fascia as in the type.

Length of body, ♂ 21.5, ♀ 30 ; pronotum, ♂ 6, ♀ 7.5 ; elytra, ♂ 22.5, ♀ 32 ; hind femur, ♂ 12.5, ♀ 17 mm.

S. Hedjaz : Qainait, 16. x. 31, 1 ♂ ; Fara, 16. x. 31, 2 ♀♀ ; Daka, 17. x. 31, 3 ♂♂ (including the *type*), 3 ♀♀ ; Barad, 3. viii. 34, 1 ♂ (*H. St. J. B. Philby*).

Yemen : Hadja, iv. 1931, 1 ♂ ; Sanaa, viii. 1931, 3 ♂♂, 5 ♀♀ (*C. Rathjens*).

Several of the Yemen specimens have yellow wings, while in others they are red as in the Hedjaz series, there being no other differences between them.

HYALORRHIPIS ARABICA, sp. n.

♀. Antennae very slender, considerably longer than head and pronotum together.

Head well raised above the pronotum. Face in profile somewhat oblique. Frontal ridge scarcely sulcate ; seen in profile nearly convex above the ocellum and slightly depressed below it. Fastigium of vertex sloping, concave, with a low median carinula, margins divergent forwards between the eyes and obsolescent in front of them.

Pronotum strongly sellate. Transverse sulci, including the submarginal one, deep ; typical sulcus well in front of the middle. Median carina present in the metazona only, very low, linear. Anterior margin ascending over the occiput, sinuate. Posterior margin well projecting backwards,

rounded. Lateral lobe higher than long; lower margin practically straight, ascending throughout; lower hind angle truncate.

Elytra well projecting beyond hind knees. Discoidal area with the false vein sinuate, approaching apically the hind radial; posterior part of the area with fairly regular transverse veinlets forming narrow cells. Interulnar area narrower than the discoidal, with two irregular rows of cells. Posterior branch of the hind radial vein with one branch; a regular false vein between the last-named branch and the anterior branch of the radial; cells of the apical part long. Apex of elytra narrow.

Upper valvae of the ovipositor large, scooped out above, with acute curved apices. Lower valvae with narrow and acute curved apices, armed with narrow subbasal teeth.

General coloration light buff, with reddish-ochraceous pattern. Pronotal disc with two light longitudinal stripes; lateral lobes whitish. Elytra with a few rather large and imperfectly defined reddish-ochraceous spots in the basal half; light stripes along the anal veins; apical part hyaline. Hind femur whitish laterally, spotted with ochraceous above. Hind tibia white. Wings hyaline.

Length of body 19; pronotum 4; elytra 21; hind femur 11 mm.

Al'ula, 29. vi. 1931, 1 ♀ (*H. St. J. Philby*).

In its striped pattern this species somewhat resembles *Leptopternis gracilis* (Ev.), while preserving the spots typical for most species of *Hyalorrhapis*. In the structure of head, pronotum, and in the armature of hind tarsus it is a typical *Hyalorrhapis*.

UTUBIUS *, gen. nov.

Very similar and allied to the Central Asian genus *Thrinchus* Fischer-Waldheim 1848, but well distinct from it by the frontal ridge not lowered suddenly under the ocellum; by the simple prosternum without a reflexed margin; and by the male subgenital plate simple, not bituberculate.

Genotype: *Utubius zahrae*, sp. n.

UTUBIUS ZAHRAE, sp. n. (Plate 11, fig. 3.)

♂. Antennae long, compressed. Vertex strongly sloping, with narrow median sulcus.

Frontal ridge above the ocellum rounded, not prominent at the fastigium, the remaining portion of it, from the upper edge of antennal scrobae downwards, is practically straight, moderately raised, only very slightly depressed at the ocellum, and gradually lowered to the clypeus. Occiput with a median carinula, which is finely sulcate along the middle.

Prozona less than half the length of metazona (5:12), with strongly raised median carina, which forms an acute tridentate tubercle, with the posterior

* *Utubi* was the name given by classical geographers to the ancient Arabian tribe which founded Kuwait.

lobe very small; surface of prozona with acute tubercles. Metazona as broad as long, moderately convex; posterior process parabolic, with the margins concave; median carina low, but sharp; surface densely rugulose and tuberculate, with a pair of large elongated tubercles near the apex. Lower margin of lateral lobes weakly sinuate.

Prosternum normal. Episternum small.

Elytra almost reaching the apex of hind tibia. Third radial vein running close to the second radial. Cross-veins thick, especially in the discoidal and interlunar areas. Wings with the two apical lobes prominent.

Anterior femur and tibia rounded. Median femur compressed, obtusely carinate; median tibia compressed, shallowly sulcate on the outer face, and denticulate along the posterior edge. Posterior femur compressed; upper carina denticulate; lower carina somewhat undulate; posterior tibia compressed, with seven outer and six inner spines, without apical spines.

Subgenital plate short, rounded. Cercus somewhat compressed laterally and feebly incurved.

General coloration light brownish, with darker and lighter streaks as in *Thrinchus*. Wing faintly greenish basally, with a narrow weak brownish fascia split up into spots, well distant from the posterior margin and not reaching the inner margin. Hind femur black on the inside. Hind tibia light yellow.

Length of body 31; pronotum 7.5; elytra 35; hind femur 15 mm.

Kuwait, iv. 1935, 1 ♂; iv. 1936, 2 ♂♂ including the type (Mrs. H. R. P. and Miss Zahra Dickson).

The group to which this remarkable new genus and species belong includes only two known genera, *Thrinchus* F. W. and *Strumiger* Zubowsky, 1896, restricted in their distribution to Russian Central Asia and Northern Persia. An occurrence of a closely allied genus in Northern Arabia is a fact of great interest, suggesting that the group is probably not Centralasian in origin, though it would be difficult to say at present anything positive on the subject.

It is to be hoped that more material of this interesting insect will be forthcoming in future.

PYRGOMORPHELLA ROTUNDATA, sp. n. (Pl. 11, fig. 4.)

A very distinct robustly built species, with rounded pronotum without keels and very short elytra.

♀. Antennae very short and thick, triquetrous in the basal fifth, rounded elsewhere.

Face in profile concave. Frontal ridge sulcate throughout, strongly compressed and prominent at the fastigium. Fastigium of vertex a little longer than broad, parabolic. Vertex and occiput with a callous median carinula. Head above with callous tubercles arranged in irregular longitudinal series. Cheeks with scattered tubercles and an oblique series of larger tubercles.

Pronotum weakly convex above, both longitudinally and transversely. Prozona rugulose and with tubercles; metazona more densely rugulose but with scarcely any tubercles, half the length of prozona. Only the typical sulcus present. Median carina obsolete; lateral carinae indicated by a concave row of tubercles. Anterior margin rounded; posterior obtusely emarginated, with the sides of the emargination broadly convex. Lateral lobes much longer than high; lower margin strongly ascending, scarcely sinuate; posterior angle rounded; posterior margin concave. Mesonotum slightly projecting beyond the pronotum. Metanotum and abdominal tergites rugulose; pleurae with a few tubercles.

Elytra quite rudimentary, lateral, reaching a little beyond the metanotum; lower margin almost straight; upper margin convex; the apex elliptical.

All femora with callous tubercles.

Coloration uniformly reddish ochraceous; some tubercles of lighter shade; some blackish dots on head, pronotum and posterior femora; a light imperfectly defined stripe along the lower margin of pronotal lobes.

Length of body 25; pronotum 5; elytra 3; hind femur 11 mm.

S. Hedjaz, Daka, 17. x. 1931, 1 ♀ (*H. St. J. Philby*).

PARASPHENA YEMENITA, sp. n.

A medium-sized slender apterous species, densely covered by callous tubercles.

♂. Antennae longer than head and pronotum together, stout, slightly incrassate basally.

Face very strongly oblique. Frontal ridge weakly prominent between antennae, sulcate throughout, obsolescent towards the clypeus. Fastigium of vertex less than half again as long as broad, slightly narrowed forward; apex broadly parabolic. Vertex and occiput with an interrupted median carina, rugulose, with a few callous tubercles. Cheeks with an oblique series of large callosities.

Pronotum densely honeycombed with punctures and provided with a few scattered callous tubercles, which are denser in the metazona. Median carina indicated by an irregular smooth line. Lateral carinae indicated in the metazona by a series of tubercles. Metazona about one-fourth the length of the whole pronotum. Posterior margin obtusely excised, margins of the excision convex. Lateral lobes much longer than high, rugulose, above with smooth depressions bordered by tubercles; lower margin sinuate, broadly callous. Mesonotum, metanotum, and abdominal tergites densely covered by callous tubercles.

Last tergite with a broadly parabolic emargination. Supra-anal plate acutely triangular, longer than broad. Cerci a little shorter than supra-anal plate, narrowly triangular, somewhat compressed laterally, with the apex slightly decurved.

General coloration greyish olivaceous, with the callous tubercles yellowish. Antennae brown underneath. Cheeks blackish blue with the oblique series of

ivory white callosities. Pronotum slightly tinted with purplish red in the upper part of the lateral lobes, which are broadly bordered with ivory-white along the lower margin. Hind femur on the outside with a dirty yellowish network on bluish grey background. Hind tibia light sanguineous.

Length of body, ♂ 20, ♀ 23; pronotum, ♂ 2, ♀ 4; hind femur, ♂ 10, ♀ 12 mm.

Yemen: Sanaa, viii. 1931, 2 ♂♂ (one the *type*), 1 ♀ (*C. Rathjens*). Type in Hamburg Museum, one male paratype in British Museum.

ADRAMITA *, gen. nov.

Allied to *Anacridium* Uvarov, 1923, but different from it in the wholly infumate wings and in the male genitalia. Male supra-anal plate elongate-trapezoidal, with the apex projecting in the middle; cerci simple conical, not longer than supra-anal plate; subgenital plate acutely conical, ascending.

Genotype: *Anacridium arabicum* Uvarov, 1930.

The species has been described by me from a female. A male from Wadi Humum near Makalla, 9–10. v. 1931 (*Dr. H. von Wissmann*), received recently from the Hamburg Museum, enables me to state that it must be removed from the genus *Anacridium* into a new one.

ACANTHACRIS RUFICORNIS YEMENITA, subsp. n.

Very similar to the South-African *A. ruficornis lineata* (Stoll, 1813), from which it differs only in the externo-median area of hind femur bearing a narrow black stripe along the basal half of its lower carina, while a similar stripe along the upper carina extends to its apical third (instead of only reaching the middle as in *A. ruficornis lineata*).

Yemen: Sanaa, 25. v. 1931, 1 ♂ (*type*); Scho ub near Sanaa, 2. vi. 1931, 1 ♂ (*Dr. C. Rathjens*). Type in the Hamburg Museum; paratype in the British Museum.

It may appear that a single pattern character indicated above is too trivial to be considered of subspecific value. However, the pattern of the hind femora is extremely constant in the long series of *A. ruficornis lineata* in the British Museum collection; moreover, the lower femoral stripe is absent in all other subspecies of *A. ruficornis*, of which very long series have been examined. That stripe, therefore, represents a character observed exclusively in the Arabian form, and can be therefore regarded as of definite taxonomic value.

The separation of the Arabian form into a distinct subspecies is further supported by zoogeographical considerations. There are four subspecies of *A. ruficornis* known in Africa, viz. *A. ruficornis ruficornis* of West Africa, *A. r. fulva* of East Africa (from the eastern part of the Cape Province northwards to Kenya and Uganda), *A. r. lineata* of S. Africa (Cape Province), and *A. r. citrina* of the Sudanese region (from Morocco to Senegal, Gold Coast, Nigeria, Sudan, Abyssinia, Eritrea). It would be not unnatural to expect

* *Adramitae* were the inhabitants of the present day Hadramaut according to Pliny.

the Arabian subspecies to resemble most closely the Sudanese *citrina*, or at least the East African *fulva*, but actually this is not the case. Indeed, *citrina* is a most aberrant subspecies, and its area of distribution cuts off that of *yemenita* from those of all other subspecies. Moreover, surprisingly enough, *yemenita* proves to be most closely allied to *lineata*, occurring only in the extreme south-west of Africa, and it would be not justifiable to regard the Arabian form merely as *lineata*, separated as it is from the true *lineata* by the whole length of a continent populated by two very distinct subspecies, *fulva* and *citrina*. It would appear, on the whole, as if *lineata* and *yemenita* are two forms most closely allied to an ancestral one and preserved now at the two extreme ends of the area inhabited by the species.

SPHODROMERUS RATHJENSI, sp. n.

Differs from all known species by the practically rudimentary wings, while the elytra are as short as in *S. sanguiniferus* Rehn, 1901, and *S. inconspicuus* Schulthess, 1894 (both from Somali).

♀. Antennae a little shorter than head and pronotum together.

Face broadly rounded in profile. Frontal ridge flat, a little constricted at the fastigium, obsolescent near the clypeus. Fastigium of vertex roundly sloping, a little broader than the frontal ridge at the ocellum, oval in shape; the surface weakly concave.

Pronotum thick, narrowed anteriorly. Disc rugulose, convex, cut by three transverse sulci, the typical one being a little in front of the middle. Median carina low, irregular. Lateral carinae thick and low in the prozona, weakly divergent towards the first sulcus, strongly divergent between the first and the third sulcus, obsolescent in the metazona. Metazona broad; posterior margin prominent, obtusely angulate. Lateral lobes higher than long, narrowed below; lower margin sinuate.

Elytra reaching the end of the fifth tergite, more than twice as long as their maximum width; apex narrowly parabolic. Wings minute (2.5 mm. long), with thick veins.

Hind femur thick. Upper carina denticulate; lower carina also dentate in the apical half, but the indentations are small, irregular, and rounded. Hind tibia with six outer and seven inner spines.

General coloration dull greyish brown, without any definite pattern. Hind femur above with very faint traces of dark bands and an imperfectly defined light ring in front of the knee; inner surface dark purplish brown, this colour overflowing on to the inner half of the lower sulcus, the outer part of which is bright stramineous. Hind tibia dark purplish brown; tips of spines black. Wings not coloured, their main veins brown.

Length of body 30; pronotum 9; elytra 11; hind femur 18 mm.

Yemen: Sanaa, ix. 1931, 1 ♀ (*Dr. C. Rathjens*). The type in the Hamburg Museum.

THISOECETRUS RANTAE, sp. n.

A small slender species allied to *T. adspersus* Redtenbacher, 1889, but well distinct from it by the very oblique face; frontal ridge constricted at the fastigium; fastigium of vertex strongly projecting forward; elytra narrow and often abbreviated; male subgenital plate without two tubercles; whole insect heavily spotted with black.

♂. Antennae longer than head and pronotum together, distinctly incrassate beyond the middle.

Face strongly oblique. Frontal ridge in profile straight; slightly widened above the ocellum, but constricted at the fastigium; surface flat. Fastigium of vertex narrow, almost horizontal, shallowly concave; viewed in profile strongly prominent forward with the surface below the level of the vertex itself, and with the anterior margin slightly raised; no median carinula.

Pronotum very slightly saddle-shaped. Transverse sulci deep, narrow. Metazona two-thirds the length of prozona. Anterior margin broadly rounded; posterior obtusely angular, with the angle rounded. Median carina fine, sharp; lateral carinae faintly indicated, irregular.

Prosternal tubercle inclined backwards, not narrowed towards the apex, which is rounded. Mesosternal lobes slightly transverse, about as wide as their interspace. Metasternal interspace very narrow.

Elytra reaching the narrow part of hind femur; narrowed towards the apex. Interulnar area narrow.

Cerci with the apical compressed part scarcely broader than the basal part; lower margin of the apical part straight. Subgenital plate very short, rounded, without tubercles.

General coloration buff, with heavy black and brown markings. Antennae black on the underside. Face ivory-yellow; frontal ridge chocolate-brown below the ocellum; sides of fastigium shining black; blackish-brown streak below the eye; mandibles chocolate-brown and black. Fastigium of vertex brown above; occiput with a velvety-black median stripe enclosing a fine pale median line; black postocular streak. Pronotum with a velvety stripe which is dark chocolate-brown, but becomes black on its margins, where it is followed by a light lateral stripe; lateral lobes light brown except a median spot and broad lower margin, which are light buff. Elytra with fairly large black and brown spots; anal area not spotted. Hind femur with the following markings in black: a streak in the upper half of the base of externo-median area, two postmedian fasciae, some dots and streaks along the lower external carina and the knee. Hind tibia light sanguineous-red in more than the apical half; the basal part stramineous with the joint and two fasciae black; spines black. Abdomen with a pair of black streaks on the side of each tergite.

Length of body, ♂ 15, ♀ 26; pronotum, ♂ 3·5, ♀ 5·5; elytra, ♂ 10-17, ♀ 15-23; hind femur, ♂ 11·5, ♀ 15·5 mm.

Aden, vii. 1932, 1 ♂, 3 ♀♀; 10 miles N. of Aden, 5. x. 1932, 4 ♀♀; 24. x. 1932, 2 ♂♂ (including the *type*), 7 ♀♀; 22. ix. 1932, 3 ♂♂, 8 ♀♀; Sheikh-Othman, 29. iv. 1932, 1 ♀; viii. 1932, 2 ♀♀ (*Mrs. M. C. Rant*).

Jidda, 7. iv. 1929, 1 ♀ (*H. St. J. Philby*).

The length of elytra is variable in both sexes, and they may sometimes be shorter than the abdomen, while often they extend beyond the hind knees. The lightly coloured parts of the body are sometimes greenish.

CYCLOPTERNACRIS (?) *OMANICA*, sp. n.

Similar to *C. hemiptera* Uvarov, 1935, of Hadramaut and Yemen, but the elytra shorter, vertex narrow, pronotum more convex and narrowed anteriorly, and differing in the coloration.

♀. Antennae broken off.

Face more oblique than in *C. hemiptera*. Frontal ridge straight in profile; surface almost flat. Fastigium of vertex narrow, concave; vertex between the eyes very narrow and deeply sulcate. Occiput with a faint median carinula. Eye distinctly less high and more rounded than in *C. hemiptera*; its horizontal diameter little more than half of the vertical; subocular distance a little less than the horizontal diameter.

Pronotum distinctly gibbose in both longitudinal and transverse directions; surface rugulose. Transverse sulci weak, except the typical one, which is placed at two-thirds of the length. Anterior margin distinctly projecting in the middle; posterior margin obtusely angulate. Median carina low, smooth. Lateral carinae weak but distinct, well divergent backwards. Prosternal tubercle short, obtusely conical.

Elytra extending to the middle of the fourth tergite; narrow, with parabolic apex. Wings a little shorter than elytra.

Hind femur relatively short and broad. Hind tibia with seven spines on each side.

General coloration dull brown. Face and cheeks with indefinite grey markings. Elytra with some indistinct dark spots. Wings colourless. Hind femur dirty yellowish, with faint traces of dark transverse fasciae above. Hind tibia faintly reddish.

Length of body 26; pronotum 6.5; elytra 10; hind femur 13.5 mm.

Muscat, ix.-xii. 1896, 1 ♀ (*Maindron*). Type in the Paris Museum.

I cannot be certain of the generic determination without knowing the male.

ASMARA PUNCTATA, sp. n. (Fig. 4; Pl. 11, fig. 2.)

Differs from the only known species of the genus, *Asmara caloptenoides* I. Bolivar, 1914, by the rugulose pronotum, metanotum and first tergite; by the shape of elytra (compare Pl. 11, fig. 1), and by that of the prosternal tubercle.

♂. Antennae longer than head and pronotum together, distinctly incrassate in the middle.

Face strongly oblique. Frontal ridge almost flat, with some fine punctures.

Fastigium of vertex sloping, very faintly concave, with a low median carinula, more pronounced between the eyes and obsolescent on the occiput.

Pronotum distinctly narrowed forwards, not constricted in the middle. Disc obtusely tectiform, practically smooth in the prozona, distinctly punctured in metazona, which is one-third the length of the whole pronotum. Median carina low, smooth, weakly gibbose in profile. Lateral carinae thick, practically smooth, gradually divergent in prozona, parallel in metazona. Front margin of the disc rounded; hind margin obtusely excised. Lateral lobe shiny, with not dense large punctures in prozona, densely and coarsely punctured in metazona. Prosternal tubercle slightly inclined backwards, obtusely conical.

Metanotum and abdominal tergites with a smooth median carina, with large but shallow and imperfectly defined punctures, becoming less distinct posteriorly.

Elytra extending a little beyond the first tergite; inner margin straight; outer margin convex; maximum width beyond the middle; all veins very thick; radial veins in the middle.



FIG. 4.—*Asmara punctata*, sp. n. Male cercus.

Last tergite represented by two widely separated lateral parts, each bearing a triangular appendage at the inner angle. Supra-anal plate elongate-oval, with a blunt triangular apex; surface with a double longitudinal swelling at the base. Cerci compressed laterally, particularly in the apical part, which is curved down and foliaceous, but not wider than the basal part. Subgenital plate short, rounded.

Dark chocolate-brown, with bright sulphurous stripes along the sides of occiput, lateral pronotal carinae and inner edge of elytra. Abdomen from the second tergite backwards blackish brown laterally and light buff dorsally. Hind femur with the externo-median areas and interno-median areas brownish grey; light yellowish underneath. Hind tibia purplish above, with indistinct pale subbasal ring; spines white, black-tipped.

♀. Antennae not incrassate in the middle. Lateral pronotal carinae punctured even in prozona; metazona strongly punctured. Metanotum and first two or three tergites strongly punctured. General coloration less contrasting, the background being castaneous and the lateral stripes light brown. Hind

femur with three wide but indefinite dark fasciae in the upper half of the externo-median area, and with three more distinct fasciae in the interno-median area; lower sulcus light red. Hind tibia more bluish than in the male.

Length of body, ♂ 19, ♀ 27; pronotum, ♂ 5, ♀ 6.5; elytra, ♂ 4, ♀ 6; hind femur, ♂ 12, ♀ 17 mm.

Yemen: Sanaa, viii. 1931, 1 ♂ (*type*), 3 ♀♀ (*C. Rathjens*). Type in the Hamburg Museum; one female paratype in the British Museum.

The genus *Asmara* has been described from the female sex alone, and this caused its author to place it into a wrong group of genera. Our new insect has been compared with the type of *A. caloptenoides* I. Bolivar, kindly sent to me by Mr. Morales Agacino from Madrid, and there can be no doubt that they are congeneric. The male of *A. punctata* shows that this genus is very closely allied to *Paraeuprepocnemis*, the male genitalia being of exactly the same type, while the differences consist in the further reduction of elytra and in the consequent emargination of posterior pronotal margin, as well as in the practically non-concave fastigium of vertex.

PARATETRIX OCELLATUS, sp. n.

Allied to the Mediterranean *P. meridionalis* (Rambur), but antennae longer and more slender, and the frontal ridge between fastigium and median ocellum regularly convex in profile.

♀. Antennae reaching nearly the base of hind femur, very slender, middle joints being about six times as long as wide.

Frontal ridge in profile regularly convex between fastigium and median ocellum, depressed and notched at the ocellum, straight below it; viewed from the front it is gradually widened towards the ocellum, sulcate throughout except quite close to the fastigium, linear below the ocellum, bifurcate near the clypeus. Ocelli relatively very large. Fastigium of vertex as in *P. meridionalis*; its front margin on a level with the front margin of the eyes; lateral margins well raised; surface concave, with a median carina. Occiput granulated and with transverse tubercles separating it from vertex.

Pronotum as in *P. meridionalis*, except that the median carina is a little more undulating in profile and the surface is covered with small granules; the part of the pronotum projecting beyond the hind knees is about one-third the length of the whole pronotum.

Anterior femur not expanded. Middle femur with the lower margin weakly expanded and slightly undulated; its width less than that of the visible portion of the elytron. Posterior femur granulated, with the upper carina finely serrated and provided with a tooth in front of the knee. Posterior tarsus very similar to that in *P. meridionalis*.

♂. As the female, but the uppermost part of the frontal ridge slightly concave in profile.

Length of body, ♂ 6.5, ♀ 9.5; pronotum, ♂ 9, ♀ 12; hind femur, ♂ 5, ♀ 6.5 mm.

Mecca, 2. iv. 1931, 1 ♂, 1 ♀; 24. iv. 31, 1 ♀ (*type*); 8. x. 31, 1 ♂; 21. x. 31, 1 ♀; 8. iv. 32, 1 ♂; 26. iv. 32, 1 ♂; 15. i.-16. iv. 34, 6 ♂♂, 5 ♀♀; 7-21. xii. 34, 2 ♂♂; 10. i. 35, 4 ♂♂, 4 ♀♀; Jidda, 26. xii. 34, 1 ♂ (*H. St. J. Philby*).

In *P. meridionalis*, as well as in *P. caucasicus* Bey-Bienko, 1933, the upper part of the frontal ridge is very distinctly concave in profile at the fastigium, becoming convex lower down. In the new species this concavity is somewhat distinct only in the male sex, while in the female either the whole upper part is very regularly convex or there is but a slight concavity at the fastigium. This character is quite constant in the long series of specimens examined, and should be of specific value. It is not impossible that the new species will prove to be synonymous with one of those described from Africa or India, but the systematics of tropical species of this genus are in such a state that an exact identification of them is scarcely possible.

HEDOTETRIX ALIENUS, sp. n. (Fig. 5.)

♀. Antennae slender, reaching posterior margin of pronotal lateral lobes.

Frontal ridge in profile above the ocellum broadly rounded, at the ocellum depressed, below it slightly convex. Fastigium of vertex narrower than an eye; its front margin scarcely behind the line connecting the front margins of the eyes; lateral margins raised, short; surface deeply concave on both sides of the median carina, which is well raised but thick, disappearing on the occiput.

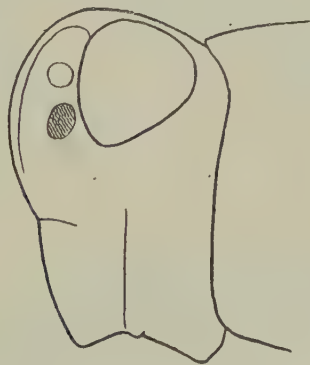


FIG. 5.—*Hedotettix alienus*, sp. n. Side view of the female head.

Pronotum tectiform, with the slopes convex. Median carina continuous, weakly convex in profile, gradually lowered at the anterior end. Lateral carinae in front of the first sulcus parallel, granulate; in the metazona divergent, acute. Surface of the disc in dense acute granules directed backwards. The posterior process extending beyond hind knee; its margins slightly undulating and denticulate. Lateral lobe with the lower hind angle acute, but its apex rounded-truncate; lower sinus a little less than 90°; upper posterior lobe about 90°, but broadly rounded apically.

Front femur with the lower carina slightly undulate. Middle femur with both upper and lower carina expanded and undulate. Hind femur with the upper carina irregularly lobate in the apical part, ending abruptly with notch at the base of the knee. Distal pulvillus of hind tarsus a little shorter than half of the tarsus; two other pulvilli short, well separated from each other.

Visible part of elytra broader than the middle femora.

Length of body, ♂ 8, ♀ 10; pronotum, ♂ 10, ♀ 11; hind femur, ♂ 4.5, ♀ 5 mm.

Arabia: Hasa, Umm a Khisa, 2. i. 1932, 1 ♀ (*type*) (*H. St. J. B. Philby*).

Iraq: Baghdad, 1923, 4 ♂♂, 10 ♀♀ (*R. W. G. Hingston*).

EXPLANATION OF THE PLATES.

PLATE 10.

Figs. 1, 1 a. *Pynodictya gracilis*, sp. n., ♂.

Figs. 2, 2 a. *Oedaleus obtusangulus*, sp. n., ♀.

PLATE 11.

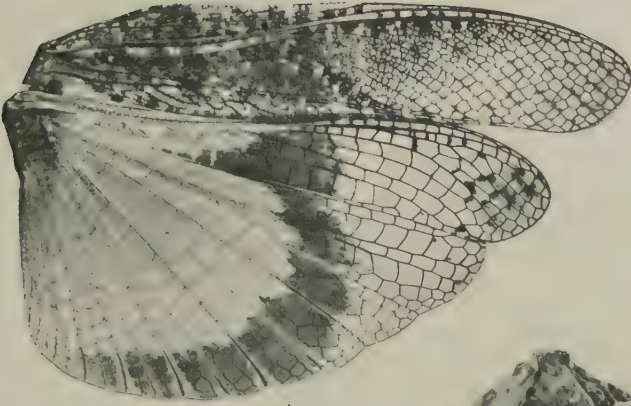
Fig. 1. *Asmara caloptenoides* I. Bolivar; elytron of ♀.

Fig. 2. *Asmara punctata*, sp. n.; elytron of ♀.

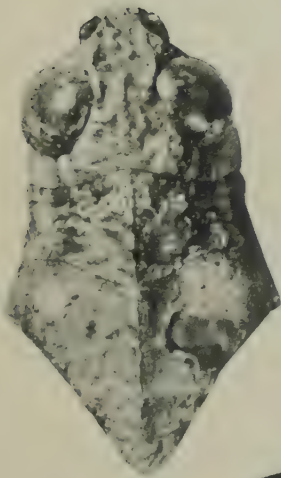
Fig. 3. *Utubius zahrae*, gen. & sp. n.; pronotum of ♂.

Fig. 4. *Pyrgomorphella rotundata*, sp. n., ♀.

Fig. 5. *Bodenheimerella arabica*, sp. n.; elytron of ♂.



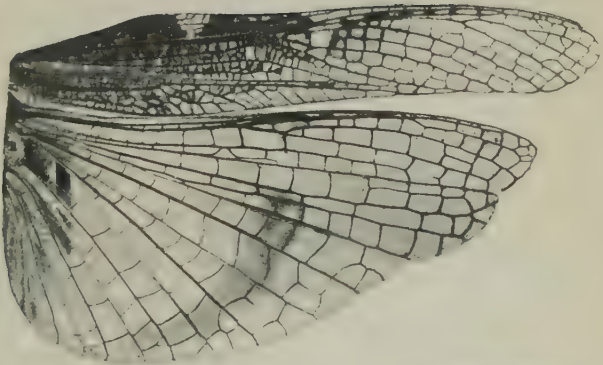
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1a



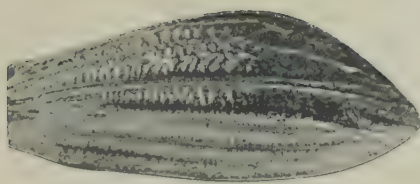
2a



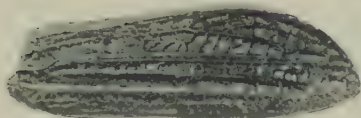
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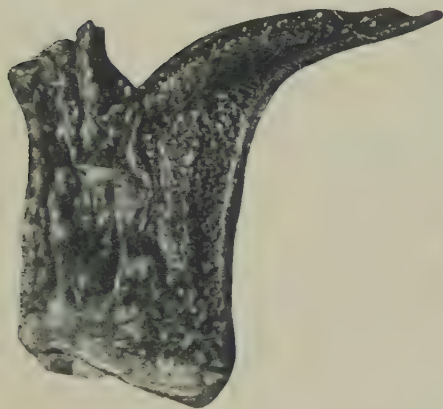
ARABIAN ORTHOPTERA



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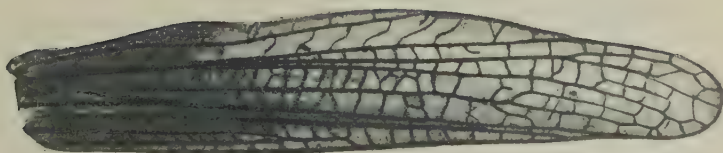
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[Synonyms are printed in *italics*. A star * denotes the first publication of a name; a dagger † denotes a fossil. The absence of an authority is due to omission by the respective authors.]

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